ASTM Bulletin

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ASTM BULLETIN

Published by
AMERICAN SOCIETY for TESTING MATERIALS

This Issue Contains

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, January 1945. Published six times a year, January, March, May, August, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 260 S. Broad St., Philadelphia 2, Pa. Subscription $1.50 a year in United States and possessions, $1.75 in Canada, $2.00 in foreign countries. Single Copies—25 cents. Number 132. Entered as second class matter April 8, 1940, at the post office at Easton, Pa., under the act of March 3, 1879.

JANUARY—1945

No. 132

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 | R. E. Hess, Editor | CABLE ADDRESS—TESTING
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Number 132 | January 1945

New Book of A.S.T.M. Standards Issued

1944 Edition Available to Society Membership and Others Interested

Owing to the unprecedented demand for the Society's most extensive publication, the 1942 Book of A.S.T.M. Standards was exhausted long before the normal three-year interval between publications had expired. It accordingly became necessary to advance the publication date of this book by one year. The latest edition, the 1944 Book of A.S.T.M. Standards, is now virtually completed and *all three parts* will soon be available. Part II has been distributed, Part I is going in the mails, and Part III will be ready late in February.

Part I, Metals.—Ferrous and non-ferrous metals (all A and B and some E serial designations) except methods of chemical analysis. General testing methods (E serial designations).
Part II, Nonmetallic Materials—Constructional.—Cementitious materials, concrete and aggregates, masonry building units, ceramics, pipe and tile, thermal insulating materials (all C serial designations). Wood and wood preservatives, paints, varnishes and lacquers, road materials, waterproofing and roofing materials, soils (certain D serial designations). General testing methods, thermometers (E serial designations).
Part III, Nonmetallic Materials—General.—Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water (remainder of D serial designations). General testing methods, thermometers (E serial designations).

The Committee on Papers and Publications again considered the advisability of changing the manner of issuing the continually increasing number of standards, emergency standards, and emergency alternate provisions which have resulted in a much larger size for each part. It was, however, deemed advisable, for the current issue at least, to publish the Book of A.S.T.M. Standards in three parts as indicated.

The Society's continued expansion in activities will undoubtedly soon necessitate publication in some other form, possibly in four or more parts, or perhaps by some radically different method, in order to make their use more practical.

Arrangement

An important change made in this 1944 edition is the inclusion (as an integral section of each part of the book) of all the emergency alternate provisions applicable to the standard and tentative standards in that part. They are to be included with the emergency standards in the pink section of the book occurring between the "standards" section in the front and the "tentatives" section in the back. The arrangement is such that each one may be readily cut from this section and pasted to the standard to which it applies if this is deemed more desirable by the individual user. Formerly the emergency alternate provisions were issued separately.

Standards are grouped (in the front section of the book) according to the various fields covered by them; for example in Part I on Metals, steel, wrought iron, cast and malleable iron, ferro alloys, etc., comprise the ferrous metals group—likewise aluminum, magnesium, copper, lead, nickel, zinc, etc., comprise the non-ferrous group. These groupings are further broken down into product classifications under each material. It is believed that such arrangement is generally more convenient than to place the standards in numeric sequence of their A.S.T.M. serial designations. The latter system would facilitate finding a single item but one would be obliged to revert continually to the classified table of contents for a list of the standards on any one subject.

Tentative standards are grouped (in the back section of the book) in a similar way to the standards.

Information Easy to Find

Although each of the three parts of the 1944 Book of Standards is a sizable volume in itself—Part I, for example over 2100 pages—it is nevertheless a simple matter to find quickly a particular specification or method of test. In addition to the comprehensive Index at the back of each part there are two tables of contents at the front, one of which is a classified listing of the standards according to the nature of the material or test subject covered, and the other a list of the A.S.T.M. standards with complete titles, according to their serial designation in numeric sequence. For users of the Book of Standards who are thoroughly familiar with the serial designations of specifications which they frequently use, the latter "Contents in Numeric Sequence" is particularly serviceable.

Growth Since Last Publication

During the two-year interval since the last publication of the Book of Standards the sixty-five committees of the Society have continued their activities with increased vigor. The new edition includes many new tentative standards accepted by the Society and a large number of former tentative specifications which have been advanced to the status of standard; also a few new emergency standards.

The accompanying table compares the new 1944 Book

A. S. T. M. Committee Week Canceled—Spring Meeting Deferred

After consultation with the Government's War Committee on Conventions, it has been decided to cancel A.S.T.M. Committee Week which had been planned for Pittsburgh, Pa., during the week of February 26—for despite the fact that much of the committee work for that week deals with production problems involving specifying and testing of war materials, it is a fact that it would bring together upwards of 500 persons in one place in a period of three or four days and the Government feels that this is most inadvisable in the present transportation emergency.

The Spring Meeting of the Society scheduled for Wednesday, February 28, is being postponed. This meeting was to comprise a Symposium on Corrosion Prevention which will be held at some appropriate time and place in the future when the present emergency has passed. Further announcement will be made concerning plans for the symposium.

So far as the Society's technical committee work is concerned, the chief consideration is that only the most essential meetings, involving attendance of less than fifty from out of town be held during this emergency. Accordingly, the Headquarters Staff is discussing with the officers of committees scheduled to meet in Pittsburgh as well as those of other committees, the arrangements for holding such necessary committee and subcommittee meetings as may be determined upon, selecting the time and place of meeting best suited to the particular group. Officers of all standing committees will be contacted as soon as the present situation is alleviated.

and 1942 edition. It is seen that there has been an increase of 59 tentative standards and 109 standards. Part I is 408 pages larger than in 1942, Part II, 168 pages, and Part III, 556 pages. These figures, however, include additional pages resulting from a section containing the emergency alternate provisions formerly issued separately. Making allowance for the increases in size resulting from the EA's, the net increase in the number of pages for the three parts is as follows: Part I, 210, Part II, 158, and Part III, 504 pages. The greatest increase in size has taken place in Part III. This is partly due to the large number of standards prepared by new committees organized during the past several years.

While there have been a few new emergency alternate provisions issued, a number of those issued in 1942 and 1943 have been withdrawn or incorporated in the standards in question with the net result of reducing substantially the number of current EA's. Committee B-5, for example, found it possible to eliminate 18 emergency alternate provisions from the cast and wrought copper and copper alloy group. The decreasing need for these emergency provisions is, of course, very gratifying.

New Specifications and Methods of Test

Obviously it would be impractical to mention all of the new tentative specifications and methods of testing appearing for the first time in this new publication. However, it might be stated that they include many diversified subjects and materials.

Part I on Metals, for example, includes four new specifications for stainless steel tubing for the dairy and food industry, refinery service and general service; specifications for stainless steel bars; and for gray iron castings for high pressure and temperature service; magnetic particle testing methods for steel castings and forgings; alternate immersion corrosion testing of non-ferrous metals; resistivity test for electrical conductors.

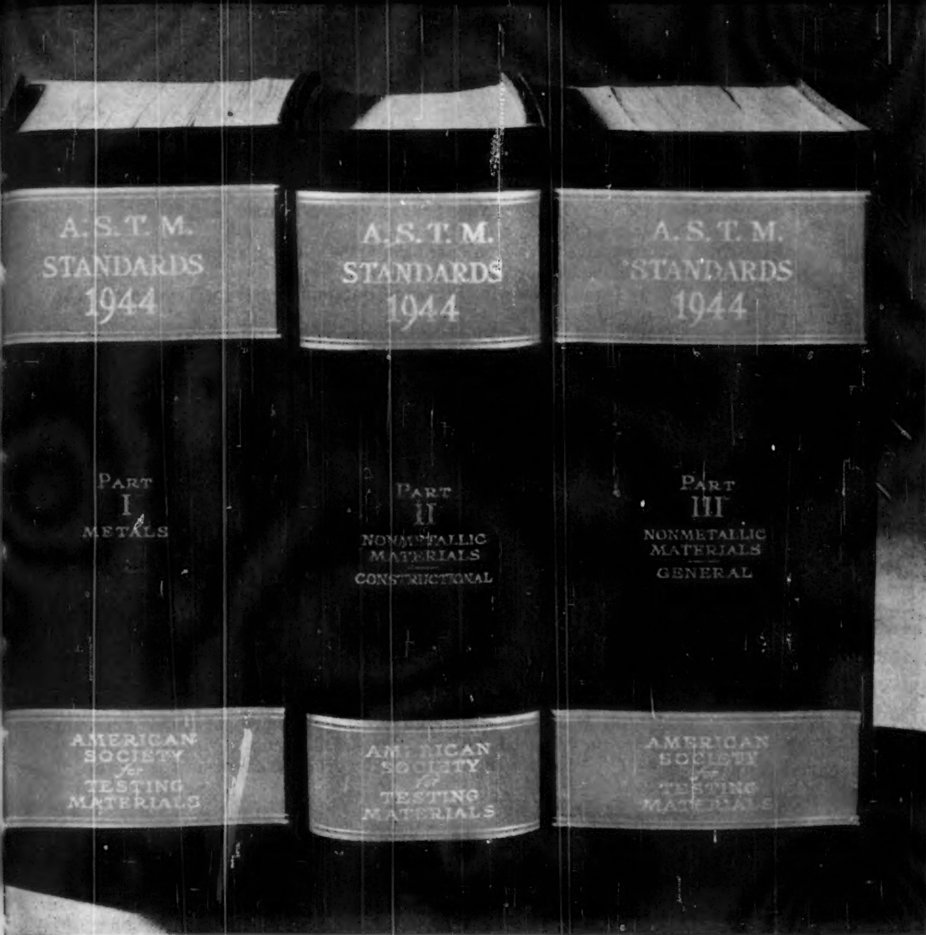
The new standards included in Part II cover revised specifications for air-entraining portland cement for concrete pavements and several specifications for magnesia, asbestos thermal and mineral wool insulating cement. Various tests for portland cement, formerly included in a single standard, have been brought up to date and issued as separate methods. Seven new specifications for pigments covering siennas and umbers; several test methods for paint including one for evaluating the degree of resistance to flaking (scaling) of exterior paints; methods of testing plywood and other wood base materials also provide important additions to this Part. The Committee on Naval Stores contributed new methods of sampling and testing dipentene, pine oil, and tall oil. New specifications for extra strength clay pipe were issued as a com-

COMPARISON BETWEEN 1944 AND 1942 EDITIONS OF A.S.T.M. BOOK OF STANDARDS.

	Number of Standards			Number of Tentative Standards			Number of Emergency Standards			Number of Pages		
	1944 Book	1942 Book	Increase	1944 Book	1942 Book	Increase	1944 Book	1942 Book	Increase	1944 Book	1942 Book	Increase
Part I—Metals	233	220	13	152	136	16	12	5	7	2098	1690	408
Part II—Nonmetallic Materials—Constructional	338	293	45	109	108	1	7	13	6*	1696	1528	168
Part III—Nonmetallic Materials—General	248	197	51	192	150	42	6	1	5	2240	1684	556
Totals	819	710	109	453	394	59	25	19	6	6034	4902	1132

* Decrease.

Actual Number of Standards (as of December 31)	796
Actual Number of Tentative Standards (as of December 31)	439
Total	1235



fabrics, and several methods for evaluation of synthetic rubbers. A new test for determining embrittling characteristics of boiler water was prepared following results of a research investigation.

Supplements to Be Issued

Following the procedure of past years, it is planned to keep the 1944 Book of A.S.T.M. Standards up to date by issuing supplements thereto in the interim years before next publication. The supplements issued for each part of the book will contain all the new and revised specifications and methods of test issued since the 1944 edition.

Method of Furnishing Book of Standards

A member of the Society is afforded the opportunity of securing any one of the three Parts of this most important publication on his annual dues and either of the two additional parts at a nominal annual charge of $3.00, or both of the two other parts for $5.00. These additional charges include the supplements published subsequently.

In addition, members may secure *extra* copies of the book at considerably reduced prices as indicated in the scale of prices given below.

panion standard to the specifications for standard strength clay sewer pipe which were also extensively revised.

Important additions to Part III include eleven new methods of testing paper and paperboard, of which the drop test and drum test for shipping containers are of particular importance because of the widespread use of containers for many war materials. In the plastics field four new specifications and a number of new test methods have been included. Four new methods for determining constituents in lubricating oils such as metals, chlorine, and phosphorus have been another important group of tests in view of the use of additives in lubricants. New specifications and tests for cellular rubber products cover the various types of sponge rubbers used extensively in aeronautic and automotive applications. Other standards on rubber cover tests for rubber adhesives, rubber-coated

Sales Prices (Cloth binding):

	Any One Part	Any Two Parts	All Three Parts
1944 Book of Standards, Parts I, II, III:			
List Prices (nonmembers)............	$10.00	$20.00	$30.00
Members Prices (for extra copies)......	6.50	13.00	19.50
Supplements for 1945:			
List Prices (nonmembers)............	4.00	8.00	12.00
Members' Prices (for extra copies).....	2.50	5.00	7.50

For half-leather binding add $1.00 for each Part and each Supplement.

Continuing Actions on Standards

Rubber Materials; Plastics; Stainless Steels; Non-Ferrous Metals

Several important new tentative standards and numerous revisions in existing specifications and test methods have been approved in recent weeks by the Society on the recommendation of various technical committees responsible. The Society has acted on these through its Committee E-10 on Standards.

The large number of items are summarized in the accompanying table and notes on some of the actions appear below. In all cases the new standards and the revisions are being published in the 1944 Book of Standards, now virtually completed. Tentative revisions of *standards* appear in the back part of each of the respective volumes

since until adopted next year or thereafter they do not affect the actual requirements, but are published for information and comment.

Forged Steel Rings for Main Reduction Gears:

The changes shown in the back of this BULLETIN involving the hardness requirements for carbon-steel rings for main reduction gears ES – 23a provide for somewhat less stringent requirements, but at the same time are satisfactory to the users well represented on the committee. Because of the size of these gears and the chemical requirements the hardness properties are difficult to obtain at best, but are essential in view of the very severe service involved.

Gray Iron Castings for Service up to 650 F.:

Culminating an extensive investigation under the auspices of the War Metallurgy Committee, and discussion at several meetings are the new tentative specifications for gray iron castings for pressure containing parts for temperatures up to 650 F. (A 278). There has been no standard covering material for use up to the indicated temperature and extensive surveys have indicated a need for such requirements; further that various classes of gray iron castings have been used successfully up to 650 F. Three classes of castings are covered with designations for tensile strengths, numbered 40, 50, and 60. While the melting procedure is optional with the foundry, castings and test bars must be stress-relieved to a temperature between 900 and 1050 F.

In the survey for the War Metallurgy Committee, over 200 specific applications at elevated temperatures were studied. Most successful applications were made with material having a carbon equivalent under 3.90 and in the range of 3.40 to 3.90 per cent. Carbon equivalent is defined as $[C + 0.3(Si + P)]$ of 3.8 per cent. The three irons included are in the high-strength class and are usually somewhat more expensive to produce because of special melting methods, alloys, and manufacturing practices. Pertinent information is given in the new standard by explanatory notes.

Automotive Gray Iron Castings:

In deciding on a number of changes in its specifications for automotive gray iron castings Committee A-3 decided to retain the standard A 159–41 and to issue the revisions in the form of a complete new tentative specification (A 159 – 44 T). The tentative specification is thus in line with provisions developed in the automotive group. The changes involve different Brinell hardness requirements, particularly the range,—modifications in transverse strength and also in the deflection. Typical basic compositions also show somewhat different chemistry than in the current standard. The tentative includes as additional material a table of residuals and alloy ranges.

Iron-Chromium-Nickel and Related Alloys:

To meet the need, apparent for a number of years, of specification requirements on hot-rolled and cold-drawn corrosion-resisting steel bars, work has been under way in Committee A-10, and resulting from this work are the new specifications for bars (A 276). Chemical analyses of the various types in the 300 and 400 series are given, together with requirements on physical properties. De-

Recent Actions by Committee E-10 on Standards

NEW TENTATIVE STANDARDS

Specifications for:

- Automotive Gray Iron Castings (A 159 – 44 T), as a tentative revision of Standard Specifications A 159.
- Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 F. (A 278 – 44 T).
- Hot-Rolled and Cold-Finished Corrosion Resisting Bars (A 276 – 44 T).
- GR-S (Synthetic Rubber) Sheath Compound for Electrical Insulated Cords and Cables (D 812 – 44 T).

Methods of:

- Total Immersion Testing of Stainless Steels (A 279 – 44 T).
- Resistance of Vulcanized Rubber and Synthetic Elastomers to Crack Growth (D 813 – 44 T).
- Permeability of Vulcanized Rubber or Synthetic Elastomers to Volatile Liquids (D 814 – 44 T).
- Hydrogen Permeability of Coated Fabrics (D 815 – 44 T).
- Rubber Adhesives (D 816 – 44 T).
- Test for Deformation of Plastics Under Load (D 621 – 44 T), to replace Standard Method D 621 – 43.
- Chemical Analysis for Acetyl and Butyryl in Cellulose Acetate Butyrate (D 817 – 44 T).
- Test for Measuring the Flow Properties of Thermoplastic Molding Materials (D 569 – 44 T), to replace Standard Method D 569 – 43.

Recommended Practices for:

- Molding Impact, Flexural and Tensile Specimens of Shock Resistant Phenolic Materials and of Mica Filled Phenolic Materials (D 796 – 44 T). (To be combined with the other recommended practices.)

REVISED TENTATIVE STANDARDS

Specifications for:

- Cartridge Brass Sheet, Strip, and Disks (B 19 – 44 T).
- Brass Sheet and Strip (B 36 – 44 T).
- Leaded Brass Sheet and Strip (B 121 – 44 T).
- Gilding Metal Sheet and Strip (B 130 – 44 T).
- Aluminum Bronze Sheet and Strip (B 169 – 44 T).
- Copper Sheet, Strip, and Plate (B 152 – 44 T).
- Naval Brass Rods, Bars, and Shapes (B 21 – 44 T).
- Copper Rods, Bars, and Shapes (B 133 – 44 T).
- Brass Wire (B 134 – 44 T).
- Phosphor Bronze Rods, Bars, and Shapes (B 139 – 44 T).
- Aluminum Bronze Rods, Bars, and Shapes (B 150 – 44 T).
- Copper-Nickel-Zinc Alloy Rod and Wire (B 151 – 44 T).
- Phosphor Bronze Wire (B 159 – 44 T).
- Copper Bus Bars, Rods, and Shapes (B 187 – 44 T).
- Copper Bus Pipes and Tubes (B 188 – 44 T).
- Flexible Varnished Tubing Used in Electrical Insulation (D 372 – 44 T).
- Black Bias-Cut Varnished Tape for Electrical Insulation (D 373 – 44 T).
- Cellular Rubber Products (D 798 – 44 T).
- Laminated Thermosetting Material (D 709 – 44 T).

Methods of:

- Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 44 T).
- Test for Power Factor and Dielectric Constant of Electrical Insulating Materials (D 150 – 44 T).
- Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 44 T).
- Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids (D 471 – 44 T).
- Testing Hard Rubber Products (D 530 – 44 T).
- Testing Automotive Hydraulic Brake Hose (D 571 – 44 T).
- Testing Cellular Rubber Products (D 552 – 44 T).
- Test for Indentation of Rubber with Durometer (D 676 – 44 T).
- Test for Resistance of Plastics to Accelerated Conditions (D 756 – 44 T).
- Conditioning Plastics and Electrical Insulating Materials (D 618 – 44 T).

TENTATIVE REVISION OF STANDARDS

Specifications for:

- Manganese Bronze Rods, Bars, and Shapes (B 138 – 43).
- Leaded Red Brass (Hardware Bronze) Rods, Bars, Shapes (B 140 – 43).

Methods of Testing:

- Flexible Varnished Tubing Used for Electrical Insulation (D 350 – 43.)
- Sheet and Plate Materials Used in Electrical Insulation (D 229 – 43).
- Accelerated Aging of Vulcanized Rubber by Oven Method (D 573 – 42).

REVISION OF EMERGENCY SPECIFICATIONS

Specifications for:

- Carbon-Steel Forgings for Rings for Main Reduction Gears (ES – 23a)

WITHDRAWAL OF EMERGENCY ITEMS

Specifications for:

- EA – A 240a Corrosion-Resisting, Chromium and Chromium-Nickel Steel Plate, Sheet and Strip, for Fusion-Welded Unfired Pressure Vessels (A 240 – 43).
- EA – C 150 Portland Cement.

pending on the condition, that is, whether cold-finished or heat-treated, and the size, the yield strengths range from 30,000 to 85,000 psi.; tensile strength from 75,000 to 125,000 psi.; elongation (gage length four times the diameter) from 12 to 35 per cent. Tolerances are given.

The new test for total immersion testing of stainless steels (A 279) does not rigorously describe any one procedure since the most desirable outline will depend upon the particular aim desired. The scope clause points out that in general, if the total immersion test is to serve as a control test for determining whether successive lots of the same material differ significantly in some property from each other, the test conditions should be arbitrarily selected and closely controlled. Then any variation in results can safely be attributed to variations in the material under test. However, if the aim of the test is to determine which of several different materials is best suited for some specific use, then the test conditions should simulate as closely as practical the conditions of service. Where factors such as the temperature and composition of the solution, aeration, etc., vary widely under service conditions, rigorous control of these factors is not necessary in conducting the test, provided all the competing materials are subjected to the same exposure conditions.

The change in the tentative recommended practice for the boiling nitric acid test (A 262) will prevent variation in procedure that has resulted in some confusion.

The Emergency Alternate Provisions EA-A 240a which have been withdrawn were put into effect along with similar requirements for certain stainless plate, sheet, and strip for industrial applications, whereas A 240 covered material primarily for boiler and pressure vessel work and the Emergency Provisions in the opinion of the committee should not be applied in this service.

Copper and Copper Alloys:

Revisions of the large number of tentative specifications for copper and copper alloys and the two standards in which tentative revisions appear as indicated in the attached list for the most part involve incorporation of the latest requirements on tolerances and permissible variations. Some of these relate to diameter, thickness, width of bars, etc. In some cases, schedules of short lengths applicable to stock lengths are covered. The incorporation of suitable permissible variations and dimensional tolerances has been an important project in Committee B-5 in the past few years. There has been cooperation between representatives of B-5, in particular consuming interests, with committees of the Copper and Brass Research Association.

Withdrawal of Emergency Specifications for Cement:

With the withdrawal on November 25 of the General Limitation Order L-179 covering the manufacture of cement the need for the A.S.T.M. Emergency Alternate Specifications for Portland Cement (EA-C 150) no longer existed and they were withdrawn on December 11. These emergency requirements were in line with the former WPB order which limited manufacture to three types of cement. This order was originally issued in August, 1942, when demands for portland cement were very high, the total production for that year being the highest on record—135,000,000 barrels.

Rubber and Rubber-Like Materials—New Standards:

Intensive work in Committee D-11 on Rubber and Rubber-Like Materials and its several subcommittees has resulted in five important new standards and revisions in six existing tentative standards. Modified excerpts from the scope clauses of the new items are given below.

Specifications for GR-S (Synthetic Rubber) Sheath Compound for Electrical Insulated Cords and Cables

These specifications cover a vulcanized synthetic rubber compound suitable for use as the outside covering, or sheath, on insulated electrical cords and cables which are not subject to severe mechanical use. These requirements cover a lower tensile jacket in relation to the Emergency Specifications for Synthetic Rubber Sheath Compound, much the same as the Specifications D 753 covering Chloroprene Sheath Compound Where Extreme Abrasion Resistance Is Not Required relate to the Specifications for Chloroprene Sheath Compound D 752.

Method of Test for Resistance of Vulcanized Rubber and Synthetic Elastomers to Crack Growth

This method is for use in determining the resistance of compounds of rubber or synthetic elastomers to crack growth when subjected to repeated bend flexing. It is particularly applicable to tests of synthetic rubber compounds which resist the initiation of cracking due to flexing when tested by Method B of the A.S.T.M. Dynamic Fatigue Tests for Rubber Products. Cracking initiated in these materials by small cuts or tears in service may rapidly increase in size and progress to complete failure even though the material is extremely resistant to the original flexing-fatigue cracking. Because of this characteristic of synthetic compounds, particularly those of GR-S, this method in which the specimens are first artificially punctured in the flex area should be used in evaluating the fatigue cracking properties of this class of material.

Method of Test for Hydrogen Permeability of Coated Fabrics

This method is intended for use in the determination of the permeability of hydrogen into air through fabrics coated with rubber or synthetic elastomers. The apparatus used is a fabric permeameter.

Method of Test for Permeability of Rubber or Synthetic Elastomers to Volatile Liquids

This method is used to evaluate the permeability of rubber or synthetic elastomers with respect to volatile liquids diffusing into air. It is applicable only to the materials in sheet form of moderate thickness and is principally useful for comparing the relative permeability of different materials to the same liquid or the diffusion of different liquids through the same material. The method is widely used in connection with airplane fuel cells, gasoline hose, and similar applications.

Methods for Testing Rubber Adhesives

These methods are used in testing the properties of adhesives which may be applied in plastic or fluid form and which are manufactured from natural rubber, reclaimed rubber, synthetic elastomers or combinations of these materials. They are not all to be considered as applicable to a particular type of adhesive nor do they necessarily include every test which may be applicable to a particular type. They do, however, provide procedures in standard form for evaluating the more important properties of the usual adhesives ordinarily classed as rubber cements. These methods have been under development for several years and should prove very helpful. There have been urgent requests for them from various organizations including branches of the Armed Services.

Classes of Tests.—The tests may be classified in two groups, the first including those procedures in which the adhesive is applied to specimens of materials to be bonded after which the quality of the bond is evaluated; and the second giving those procedures applicable to the adhesive itself without consideration of the bonding properties. The tests in class 1 are those for adhesion strength, bonding range, softening point and cold flow. Those in class 2 comprise determinations of viscosity, stability, cold brittleness, weight per gallon and plastic deformation (for heavy doughs or putties). (*Continued on page 39*)

The Determination of the Terpene Alcohol Content of Steam-Distilled Pine Oil[1]

By V. E. Grotlisch[2] and H. N. Burstein[3]

STEAM-DISTILLED pine oil is a mixture of terpenes obtained from the heartwood of old longleaf yellow pine stumps by a steam and solvent recovery process. It consists essentially of tertiary terpene alcohols (chiefly alpha-terpineol), and the secondary alcohols borneol and fenchyl alcohol, together with relatively smaller quantities of terpene hydrocarbons, such as alpha- and beta-pinene and dipentene, and the terpene ethers cineol, methyl chavicole, and anethole.

The principal uses of pine oil are as a frothing agent in the flotation process of ore recovery in the mining industry, as a penetrant and a wetting agent in the scouring of wool, and as a thinner and setting retardant in some types of paint and varnish. Pine oil is also used in the manufacture of insecticides, disinfectants, cattle dips and sprays, as a perfume or counterodorant in cleaning compounds, and as a source of certain chemicals and pharmaceuticals—terpene alcohols and their derivatives and terpin hydrate.

The commercial value of pine oil, for most of these uses, is dependent primarily upon its terpene alcohol content, and to a lesser extent, upon the absence of moisture. The high-gravity, light-colored commercial pine oils contain the highest percentage of alcohols and are almost anhydrous. In spite of the importance of the alcohol content of pine oil, methods used in the industry for determination of terpene alcohols when this study was begun in December, 1942, had not been completely standardized.

Correspondence with several pine oil producers regarding their methods of test brought forth opinions that the methods were not entirely satisfactory but were the best available. This study was undertaken to explore the possibilities of standardizing existing methods as well as of developing new methods of determining the alcohol content of pine oil.

Evaluation of Selective Terpineol Dehydration

Some of the methods studied during the initial stages of this work were concerned with the determination of only the terpineol content of pine oil and were based on the supposition that only this constituent breaks down to water and dipentene when the pine oil is boiled with a weak catalyst in the presence of sufficient mineral oil to keep the temperature down. Although this principle could be applied to industrial separations,[4] its quantitative application was open to question.

One procedure called for a certain amount of refluxing with phthalic anhydride, to protect the secondary alcohols by esterification, before proceeding with the dehydration of the terpineol. Our experiments showed that only a partial esterification takes place in any reasonable length of time. According to the work of Chadwick and Palkin (*1*),* it was necessary to reflux fenchyl alcohol and phthalic anhydride in benzene solution for 48 hr. in order to prepare the acid phthalate in substantially quantitative amount. This, of course, is entirely impractical for an analytical procedure.

By increasing the quantity of mineral oil present, an attempt was made to find a minimum temperature at which terpineol would be dehydrated without affecting the secondary alcohols. This was also unsuccessful, as the temperature at which complete dehydration of terpineol occurred was also high enough to cause decomposition of some of the secondary alcohols.

Experimental Procedure for Selective Terpineol Dehydration.—Samples of the tertiary and secondary alcohols, and known mixtures containing alpha-pinene to simulate various types of pine oil, were selected for study.

A 100-g. portion of each sample, to which had been added an equal quantity of mineral spirits (Varsol), was dehydrated by using weak catalysts of the type recommended for selective tertiary alcohol dehydration. These included fuller's earth, metallic copper and a trace of iodine, and solid potassium acid sulfate.

Some runs were made with a preliminary refluxing with phthalic anhydride. Additional runs were made in which the volume of mineral oil present was increased to permit the dehydration to take place at lower temperatures.

The water liberated was collected in a Barrett-type moisture trap, and the terpineol content of the mixture calculated and compared with the amount of terpineol known to be present.

The results presented in Table I show conclusively that

TABLE I.—PERCENTAGE DEHYDRATION OF TERPENE ALCOHOLS, USING WEAK CATALYSTS.

Alcohols Present, per cent		Alpha Pinene, per cent	Catalyst or Method Used	Indicated percentage of Tertiary Alcohols
Tertiary	Secondary			
100	...	..	Copper and I_2, 8 hr. at 171 C.	Variable, up to 100
100	...	..	Solid $KHSO_4$, 5 hr. at 176 C.	100
100	...	..	Copper and I_2, 4 hr. at 147 C.[a]	30
100	...	..	Solid $KHSO_4$, 4 hr. at 116 C.[a]	30
100	...	..	Fuller's earth (numerous runs)	Variable, all less than 100
25	...	75	Fuller's earth (one run)	13
...	100	..	Copper and I_2	58
...	100	..	Fuller's earth	77
...	100	..	Phthalic anhydride, fuller's earth	43
42	19	39	Fuller's earth	60
60	20	20	Phthalic anhydride, fuller's earth	67 to 70
60	20	20	Copper and I_2	53 to 63

[a] Reflux temperature decreased by addition of excess quantity of mineral oil.

* The italic numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] Contribution from the Cotton and Fiber Branch, Office of Marketing Services, War Food Administration, Washington, D. C.

[2] Chairman, A.S.T.M. Committee D-17 on Naval Stores. Chief, Naval Stores Section, Cotton and Fiber Branch, Office of Marketing Services, War Food Administration, Washington, D. C.

[3] Chemist, Naval Stores Section, Cotton and Fiber Branch, Office of Marketing Services, War Food Administration, Washington, D. C.

[4] "Method of Separating Certain Components from Pine Oil," U. S. Patent No. 1,932,183, October 24, 1933.

TABLE II.—PERCENTAGE DEHYDRATION OF TERPENE ALCOHOLS, USING FULLER'S EARTH AND PHOSPHORIC ACID CATALYSTS.

Alcohol	Calculated percentage of Alcohols
Terpineol liquid (practical grade)	104.3, 104.1, 105.0 [a]
Terpineol (recrystallized, melting point 37 to 39 C.)	100.3, 99.5, 101.1, 98.4, 99.2, 100.6, 99.4, mean 99.8
Fenchyl alcohol (technical)	100.2, 97.5
Borneol (pure)	99.1, 99.4

[a] High results probably due to dissolved moisture.

terpineol is not completely dehydrated in all cases by these catalysts, with time and temperature both affecting the results to a large degree. On the other hand, borneol and fenchyl alcohol are also substantially dehydrated (up to 77 per cent) by fuller's earth alone. Hence, the above type of procedure cannot be used to measure the terpineol content of pine oil quantitatively.

Selective halogen addition to the terpene alcohols was also tried and discarded, since quantitative halogen addition to terpene alcohol mixtures was impossible to control, due to substitution on all the alcohols.[5] Other investigators have come to the same conclusion concerning halogen addition as a means of measuring unsaturation in the terpene series (*2*).

Although there is evidence to indicate that the terpineol content of pine oil could be determined by catalytic hydrogenation after removal of all terpene hydrocarbons, as in the borate method described later in this paper, this was not attempted, as it was felt that such an involved method, using special equipment of high initial cost and requiring considerable skill in its manipulation, was not suitable for a standardized analytical procedure.

Total Terpene Alcohol Dehydration

It was decided that a method of estimating the total alcohol content of pine oil, rather than the terpineol content alone, would best serve as a means for evaluating the product, until such time as a satisfactory procedure for terpineol assay could be developed. Ono, Hirayama, and Matsuzaki (*3*) had shown that the various terpene alcohols could be quantitatively dehydrated by using phosphoric acid as the catalyst. As variations of this procedure were evidently being used in several commercial laboratories, it was considered desirable to study and attempt to standardize it.

In this connection it is to be noted that this is not a simple dehydration to dipentene and water, as it has been shown (*4*) that when terpineol is dehydrated the resulting end product consists of a mixture of dipentene, terpinene, terpinolene, and lower boiling menthadienes, as well as unidentified high boiling products, probably terpene polymers.

In order to test the effectiveness of a proposed method, using small quantities of both fuller's earth and phosphoric acid at the same time, on the terpene alcohols found in American pine oil, the dehydration was carried out on several samples of alcohols as follows:

Experimental Procedure for Catalytic Dehydration.—A 0.1-g. portion of fuller's earth was weighed into a tared, 250-ml. round-bottom flask containing a few glass beads. A 100-g. portion of a known solution of the alcohols in pinene was pipetted into the flask along with 0.3 ml. of syrupy phosphoric acid. The flask was connected to a Barrett-type water trap[6] fitted at the top with a reflux condenser, and at the bottom with a rubber tube and movable mercury reservoir.

After bringing the mercury level up into the graduated leg of the trap to $^1/_2$ in. below the side tube, gentle heat was applied until the reaction started. The reaction proceeds vigorously at first with very little heating. The water and hydrocarbons formed were collected in the trap, the mercury level being lowered, when necessary, to retain the water. When the reaction appeared to have slowed down, as indicated by a slow increase in the volume of water collected, most of the hydrocarbons were returned to the flask by raising the level of the mercury in the trap. Then the mercury level was again lowered to permit continued distillation and trapping of the distillate. After several such operations, and when it was evident that no more water was being liberated, the distillation was stopped. Each milliliter of water collected in the trap represents 8.56 g. of terpene alcohol having a molecular weight of 154.14. The results are shown in Table II.

From these results it could be concluded that this method should prove satisfactory for determining the total alcohols in pine oil, but it seemed desirable to obtain further proof that such a conclusion was justified. (Cineole would also be dehydrated along with the alcohols, thereby tending to give high results, but since the cineole content of pine oil is quite small, it was felt that this would not have a material effect on the results obtained by this method.)

Application of Other Methods of Alcohol Determination

As an entirely different approach to the problem, consideration was given to other possible methods based on conversion of the alcohols to esters or to compounds other than water. Here three procedures seemed to possess possibilities, namely, acetylation, the Zerewitinoff method (*5*), and the Kaufmann borate procedure (*6*).

Acetylation:

Although the terpene alcohols borneol and menthol react quantitatively with acetic anhydride to form acetates, the reaction in the case of tertiary alcohols does not proceed to completion, due mainly to the opposing reactions of hydrolysis and dehydration. Chemists in the laboratory of Schimmel and Co. (*7*) found that after 45 min. only 84.4 per cent of linalool had been esterified, and after 120 min. there was only 77.9 per cent of ester left in the reaction mixture. From this it was assumed that decomposition of both ester and alcohol begins before acetylation is complete. A. Verley and F. Bölsung (*8*) tried to acetylate terpinol quantitatively in pyridine solution, but this variation of the procedure also failed due to decomposition as above. In the face of such evidence, acetylation was disregarded as a means of determining the alcohol content of pine oil. It has not yet been possible to explore the possibilities in the analysis of pine oil of several more recent modifications of the esterification procedure, in-

[5] Wijs iodine procedure, Klimont bromine method (*Arch. Pharm.*, Vol. 250, p. 579 (1912)), and thiocyanogen addition were all tried and found unsuccessful. For a further study, see Joshel, Hall, and Palkin, *Ind. Eng. Chem.*, Analytical Edition, Vol. 13, p. 447, July 15 1941.

[6] Later, a specially designed, more accurate and more suitable water trap was provided for this method. Its design is shown in Fig. 1 of the A.S.T.M. Tentative Methods of Sampling and Testing Pine Oil (D 802 – 44 T), 1944 Book of A.S.T.M. Standards, Parts II and III.

TABLE III.—PERCENTAGE OF ALCOHOLS FOUND IN TERPENE HYDROCARBONS AND ALCOHOLS BY ZEREWITINOFF METHOD

Sample	Alcohols Found, per cent
Alpha-pinene	0
Beta-pinene	0
Dipentene	0
Anethole	0
Terpineol[a]	99.4, 100.7
Borneol[b]	93.3, 94.0
Fenchyl alcohol[c]	97.7, 98.9
49 per cent total alcohols, 51 per cent other terpenes[d]	48.4, 50.6
68 per cent total alcohols, 32 per cent other terpenes[d]	68.0, 68.2

[a] Recrystallized from EK terpineol.
[b] E. & A. pure borneol.
[c] Technical grade, supplied by Givaudan-Delawanna Inc., New York, N. Y.
[d] Mixtures of terpineol, borneol, and fenchyl alcohol with pinene and dipentene, prepared as percentages by weight.

cluding a formylation process in special solvents. It is hoped that this can be done in the near future.

The Zerewitinoff Method:

The Zerewitinoff method determines the active hydrogen content of a material and is therefore adapted to the alcohols. Its further study was suggested by Zerewitinoff's recorded successful results with the terpene alcohols themselves (*9*). The method depends essentially on the reaction between the alcohols and methyl magnesium iodide (Grignard reagent), with the evolution of methane, the volume of which serves as a basis for the calculation of the alcohol content. The authors successfully repeated Zerewitinoff's results, as shown by the data in Table III. No immediate explanation can be advanced for the slightly low values obtained by us for borneol, but they are not considered to be of particular concern, in view of the relatively small percentages of this secondary alcohol in natural pine oils. Particularly gratifying were the findings that the terpene hydrocarbons and ethers would not interfere with the action of the Grignard reagent. Zerewitinoff had previously stated that fenchone, camphor, and menthone also did not interfere.

A series of tests were then run on three authentic samples of steam-distilled pine oil, all of which had previously been tested by the dehydration method. The procedure outlined below was followed. Results are tabulated in Table IV.

Experimental Procedure for Zerewitinoff Method.—A 0.17 to 0.30-g. sample was accurately weighed out into the large compartment of a special Zerewitinoff tube, and dissolved in 15 ml. of dry xylene. Five milliliters of Grignard reagent in dry diisoamyl ether (or in dry phenetole) were then pipetted into the small arm of the reaction tube, and the tube connected to a water-jacketed gas burette of the Lunge type, containing mercury and fitted with a leveling tube.

The stopcock of the burette was removed for a moment to equalize the gas pressures, and then, with the stopcock opened to the atmosphere, the leveling tube was raised until the burette was filled with mercury. The stopcock was then closed.

The solutions in both arms of the reaction tube were then brought together, and at the same time the gas burette was opened to the reaction tube. The evolved methane was kept at atmospheric pressure by lowering the leveling tube. The reaction tube was shaken vigorously for several minutes until no more methane was evolved. The system was allowed to come to equilibrium, and the volume of methane read. The percentage of alcohols in the sample was computed as follows:

$$\text{Alcohols, per cent} = \frac{V_0 \times 0.000719 \times 154.14 \times 100}{16W} - 8.56M$$

where:

V_0	=	volume of methane corrected to 0 C. and 760 mm. pressure and corrected for the vapor pressure of xylene,
154.14	=	molecular weight of the alcohols sought,
W	=	weight of sample taken,
0.000719	=	weight of 1 ml. of methane at standard conditions,
16	=	molecular weight of methane, and
M	=	percentage of moisture in sample.

The values obtained were in most cases slightly lower than those obtained by the dehydration method. It must be remembered that the latter tends to give slightly high results, whereas the Grignard reagent method gave slightly low results with the secondary alcohols. If the values in Table IV showing a deviation from the dehydration method of more than 2 per cent on sample B, and more than 4 per cent on sample C, were eliminated from the calculations, then the mean values for total alcohols become 77.5 and 71.2 per cent, respectively, which are less than 1 per cent off from the dehydration values. We believe that it is safe to conclude that the Zerewitinoff method can be used for determining the total alcohol content of pine oil within a maximum probable error of ±3 per cent.

The method seems especially adaptable to the plant control laboratory because of the speed with which individual samples can be tested, as well as to the central testing

TABLE IV.—ANALYSIS OF PINE OILS FOR TOTAL ALCOHOL CONTENT BY ZEREWITINOFF METHOD FOR ACTIVE HYDROGEN.

Pine Oil A 81.5; 81.3; 81.5; 81.0; average 81.3 per cent by dehydration					Pine Oil B 78.5 per cent by dehydration					Pine Oil C 73.1 per cent by dehydration				
Weight of Sample, g.	Volume of Methane (corrected), ml.	Alcohols Found, per cent	Deviation from Mean, per cent	Deviation from Dehydration Value, per cent	Weight of Sample, g.	Volume of Methane (corrected), ml.	Alcohols Found, per cent	Deviation from Mean, per cent	Deviation from Dehydration Value, per cent	Weight of Sample, g.	Volume of Methane (corrected), ml.	Alcohols Found, per cent	Deviation from Mean, per cent	Deviation from Dehydration Value, per cent
0.1889	21.8	79.9	0.1	1.4	0.3039	33.4	76.1	1.0	2.4	0.2104	20.8	68.3	1.7	4.8
0.1997	22.5	78.1	1.9	3.2	0.1862	20.7	77.1	0	1.4	0.2062	21.5	72.1	2.1	1.0
0.2794	32.2	79.8	0.2	1.5	0.2838	32.3	78.9	1.8	0.4	0.2791	29.0	72.0	2.0	1.1
0.1951	22.7	80.5	0.5	0.8	0.2051	22.6	76.6	0.5	1.9	0.2090	20.7	68.5	1.5	4.6
0.2470	28.9	80.9	0.9	0.4	0.1902	21.1	76.6	0.5	1.9	0.2287	23.3	70.3	0.3	3.2
0.2665	31.1	80.8	0.8	0.5	0.1774	19.5	75.9	1.2	2.6	0.2538	26.2	71.4	1.4	1.7
					0.2572	28.8	77.5	0.4	1.0	0.2132	21.2	68.7	1.3	4.4
					0.2630	29.2	76.8	0.3	1.7	0.2558	25.5	70.0	0	3.1
					0.2529	28.8	78.8	1.7	0.3	0.2446	24.4	69.1	0.9	4.0
Mean		80.0	0.75	1.3	....	..	77.1	0.8	1.5	....	..	70.0	1.25	3.1
Maximum Deviation		..	1.9	3.2	....	..	..	1.8	2.6	....	..	..	2.1	4.8

laboratory where frequently only small quantities of sample are available. It is hoped that further study may result in eliminating some factors, not now evident, which caused the wide variations recorded.

The Kaufmann Borate Procedure:

A. A. Kaufmann (*6*) showed that higher alcohols can be separated from other constituents of a mixture by the use of ethyl borate. This method involves five steps: (*a*) the conversion of the alcohols to their nonvolatile borates, (*b*) removal of the nonalcoholic constituents from the reaction mixture, (*c*) hydrolysis and regeneration of the terpene alcohols, (*d*) extraction, washing, and drying of the extracts, and (*e*) removal of the solvent and weighing the recovered terpene alcohols. Chadwick and Palkin (*1*) used this method, but with butyl borate instead of ethyl borate, in their examination of steam-distilled wood turpentine. For use with pine oil, several modifications of their procedure were found necessary.

Several different mixtures containing known amounts of terpene alcohols were first analyzed, followed by two samples of steam-distilled pine oil which had previously been tested by dehydration. The procedure outlined below was followed:

Experimental Procedure for Borate Method.—Fifty grams of sample, 40 g. of *n*-butyl borate (*10*) and 20 g. of xylene were heated with constant stirring at 70 C. for 30 min. at 60 mm. pressure, using an oil bath. The temperature of the bath was raised and the pressure lowered to distill off the solvent, excess reagent, butyl alcohol, and nonalcoholic portions of the sample. The distillation was continued for some time at 4 mm. pressure and at a bath temperature of 125 C., and finally stopped when no more distillate came over.

The residue of mixed terpene alcohol borates was then transferred to a separatory funnel and hydrolyzed, merely by shaking with 200 ml. of 5 per cent NaOH solution, and the liberated alcohols were extracted with several portions of petroleum ether. The combined ether extracts were washed until free of butyl alcohol, and subsequently dried over anhydrous sodium carbonate. Finally the solvent was removed by evaporation under reduced pressure. The isolated alcohols were weighed.

It was at first thought that the method could be shortened by weighing the terpene alcohol borates obtained after the first vacuum distillation of the reaction mixtures, and computing the percentage of alcohols from this value. After many experiments it was concluded that this was not possible, as the results were not uniform. Whether an explanation of this lies in the fact that the borate esters formed did not always possess the same structures is not certain, but the results pointed in that direction. It is possible that the reactions proceeded in such a way as to cause varying relative amounts of boric acid esters to be formed, wherein one, two, or possibly three terpinyl groups replaced the *n*-butyl groups on the boron atom. When the same idea is carried further and applied to the secondary alcohols, the number of mixed terpinyl-fenchyl-butyl borates possible is evident, and it can readily be realized why any idea of using a gravimetric factor in connection with the weight of the borate residues had to be abandoned in favor of the longer hydrolysis procedure.

Results obtained by the above procedure on the pure alcohols and mixtures thereof were very close to the theoretical, as shown in Table V. In the case of the two steam-distilled pine oils, results averaged about 1 per cent lower than the results obtained by dehydration. However, as previously pointed out, dehydration results may sometimes be slightly high, while on the other hand, there is a possibility of a slight loss of material in the borate method due to handling through the various steps, and to volatilization of traces of terpene alcohols under vacuum.

TABLE V.—PERCENTAGE RECOVERY OF ALCOHOLS BY BORATE METHOD.

Alcohols Present in Known Mixture, per cent	Alcohols Found, per cent
75.6[a]	75.6
100.0,[a] several mixtures	97.5, 100.0, 99.1, 99.2, 98.0, 99.2, 100.0, average recovery 99.0
0.0[b]	0.0
74.0[c], by dehydration	73.2
78.5[d], by dehydration	77.0

[a] Synthetic mixtures of terpene alcohols and hydrocarbons made up by weight.
[b] A mixture of alpha pinene and dipentene from commercial sources.
[c] Regular steam-distilled pine oil.
[d] Steam-distilled pine oil, same as sample B in Table IV.

An important advantage of the borate procedure lies in its applicability to all pine oils regardless of interfering substances. The presence of any dihydroxy alcohols or terpin hydrate in a pine oil would result in excessive values for alchol content where the dehydration or the Zerewitinoff procedures are employed, since each mole of polyhydroxy alcohol contains two or three moles of measurable hydroxyl. Using the borate procedure such error would be avoided, as only the actual weight of the terpene alcohols is involved. Although ordinary terpin hydrate, the hydrate of 1,8-terpin, occurs to only a slight extent in fresh essential oils, it may be formed in many of them on long standing (*11*). In the case of synthetic pine oils, there is reason to believe that small amounts of terpin and terpin hydrate are present, since such pine oil can be made from pinene through a terpin hydrate process, with a yield up to about 89 per cent of terpineol (*12*). One synthetic pine oil tested in this laboratory showed an alcohol content, as determined by dehydration, 12 per cent higher than the results obtained by the borate method. The moisture present in the sample as subsequently determined accounted for 6 per cent of the difference leaving an additional 6 per cent unaccounted for, which may have been due to the presence of a small amount of unconverted polyhydroxy terpene compounds.

Dissolved moisture is also a serious interfering factor where dehydration or the Grignard reagent is employed, and must be determined by some reliable procedure and deducted from the alcohol figure. Water content does not affect the Kaufmann procedure. Finally, of course, the Kaufmann method offers a means of isolating the alcohols of a pine oil for further study, processing or identification.

Conclusions

The determination of tertiary and secondary alcohols in pine oils cannot be made with any degree of accuracy by any of the selective dehydration procedures so far proposed. The amount of tertiary alcohols could not be determined by measurement of the amount of unsaturation.

The total terpene alcohol content of pine oil can be determined by dehydration with fuller's earth and phos-

phoric acid. The Zerewitinoff procedure for active hydrogen is also suitable for determining total alcohols in steam-distilled pine oils since it gives results in fairly good agreement with the dehydration method within a limit of error not out of keeping with the recognized and accepted deviations for many other test methods applied to naval stores products.

The Kaufmann borate procedure may be used to check the results obtained by either of the above methods, and also provides a method by which the combined alcohols may be recovered from a pine oil, if desired for further study.

In the first and second procedures mentioned, the amount of moisture present as such in a pine oil must be taken into account, since each percentage of such dissolved moisture, if not allowed for, would erroneously increase the computed percentage of terpene alcohols by 8.56 per cent. A further study of methods for determining the moisture content of pine oil, as well as of drying samples preparatory to analysis, is being made.

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United Nations Standards Committee

THE NEWLY ORGANIZED United Nations Standards Coordinating Committee has opened a New York office, and in order to carry out its work effectively, the committee will maintain another office in London. The London office is operating under the direction of Charles C. LeMaistre, former Director of the British Standards Institution. Mr. H. L. Wollner who is in charge of the New York office has had wide experience in his many years work in the Treasury Dept. which will be helpful in the activities of UNSC. Each office will work with a certain group of countries, and each will keep the other in close touch with its activities.

The purpose of this new United Nations Standards Committee is to "spark plug" cooperation between the allied belligerent countries in standardization matters as an aid to production and use of war supplies and equipment and also in relief work. It seeks to secure the maximum possible coordination of standards necessary for the war effort and for the immediate postwar period.

Planning for this new international Committee has been done at a series of meetings in Washington, New York, Toronto, and London. The London meetings were attended by delegates from Australia, Canada, Great Britain, New Zealand, and the United States, and by a Russian observer. South Africa, while not able to attend the meetings in London, has already expressed her intention of joining UNSC and helping support it. Invitations to join have been issued to Mexico, Brazil, and China.

The committee is set up to operate for a period of two years with review of the need at the end of that time. Participation in the work during that time will be open to the national standardizing bodies of such of the United Nations as may desire to participate in and support the work.

Among the first jobs that the new committee has been requested to undertake are: (1) work on building materials and equipment requested by the Industrial Rehabilitation Division of the UNRRA; (2) standardization of flat bottom rails needed to rebuild the heavily damaged transportation systems of France and the other occupied countries, suggested by the Inter-Allied Transportation Committee; (3) a project for the suppression of radio interference suggested by the British Standards Institution.

New Rubber Laboratory in the Amazon Valley

IN 1942, at the request of the Brazilian Government, the National Bureau of Standards loaned the services of Dr. Norman Bekkedahl of the Bureau's Rubber Section to direct the establishment of a modern rubber laboratory at the Instituto Agronomico do Norte located in Belem in the State of Para. Dr. Bekkedahl recently returned from the laboratory and reports that it is now completely equipped and in operation, while its staff continues to be built up.

The Instituto Agronomico do Norte is one of several research institutes supported by the Brazilian Government and is somewhat similar to the Regional Research Laboratories of the United States Department of Agriculture. The director of the Instituto, Dr. Felisberto Cardoso de Camargo, has concentrated the research program largely on rubber, since it is the most important export of the Amazon region.

According to the *Technical News Bulletin*, National Bureau of Standards, plans are being made for continued cooperation between the new laboratory and the Bureau and other organizations in the United States for the development of improved methods of testing and grading natural rubber, and for fundamental research on rubber of different origin and treatment.

Federal Specification on Grain Size

SUPPLEMENT A to Federal Specifications QQ-M-151 covers the Classification of Austenitic Grain Sizes in Steel. The Supplement dated September 30, 1944, thus becomes part of the General Specification for Inspection of Metals. The charts classifying austenitic grain size are identical with those given in the A.S.T.M. Standard E 19 comprising the idealized form for grain size; the other the structures found from the McQuaide-Ehn test in a carburized case. Copies of this Supplement can be obtained from the Superintendent of Documents, U. S. Government Printing Office at 10 cents.

Life Testing of Lubrication Oil[1]

By H. C. Mougey[2]

ONE OF THE differences in behavior between the human race and the lower animals is the practice in which members of the human race frequently indulge of trying to predict the future. When no apparatus is used this practice is called "thinking" or "worrying." In another method in which only a small amount of glass apparatus is used, it is called "crystal gazing." In another method in which the glass apparatus is a little more elaborate, it is called "chemical analysis," and in another method in which the apparatus is still more elaborate, it is sometimes called "life testing." None of these methods are always 100 per cent perfect, but by using combinations of these and other methods, it is frequently possible to make very accurate predictions.

Of course, the real distinction between these different kinds of testing does not lie in the type of apparatus, but rather in the kind of testing that is done. If we want to know whether an apple is good to eat we may examine it for certain properties, such as color, shape, hardness, etc. We may then predict from these tests, which are valuable for identification purposes, whether or not the apple is good to eat. However, there is an old saying, "The proof of the pudding is in the eating," and by actually eating the apple we may determine with a much greater degree of accuracy whether or not it is good to eat.

If we are interested in oil instead of apples, we may use somewhat analogous test procedures. We may determine the properties of an oil and predict its performance from these properties. This practice is followed in using the conventional oil specifications. However, we may also evaluate the oil by determining whether or not it will actually be satisfactory in use in an engine under known operating conditions. If we do not want to make an elaborate test, we may determine how the oil performs in some kind of apparatus in which we try to simulate actual service, or at least some of the factors of actual service. In the ideal laboratory life test all factors promoting deterioration or failure are greatly intensified, while their correct relation and sequence are maintained. Life tests and accelerated laboratory tests serve a useful purpose in so far as they give information in a much shorter time, facilitate the testing of a much larger number of products than would be possible otherwise, help eliminate unsuitable materials, and afford a more intelligent selection for service tests and future use.

The importance of engine oils has been recognized since the very early days of the automotive industry, but the difficulties in testing oils have also been recognized. At a meeting of the Society of Automotive Engineers in 1909 Prof. Carpenter said (*1*):[3] "There is no known testing, I think, in the world which can give as erroneous opinions or give as erroneous results as what we get in testing oils." Although much progress has been made during the 35 yr. since these remarks were made, the subject is still rather difficult.

The first S.A.E. specification for automobile engine oil that I can find is Specification No. 26, printed in the *Transactions* of the Society of Automobile Engineers for 1910: (2)

AUTOMOBILE ENGINE LUBRICATING OIL
SPECIFICATION No. 26

Oil for this purpose must be a pure mineral oil, no addition or adulterant of any kind being permitted.

The following characteristics are desired:

Specific Gravity	28 deg. to 32 deg. Baumé
Flash Point, not less than	400 F.
Fire Test, not less than	450 F.
Viscosity at 100 F., Saybolt Viscosimeter, not over	300 sec.
Viscosity at 210 F., Saybolt Viscosimeter	40 to 50 sec.
Viscosity at 210 F., Tagliabue Viscosimeter	60 to 65 sec.
Carbon Residue, not over	0.50 per cent

It will be noted that this specification, for all practical purposes, simply limits the oil to one of from 40 to 50 sec. at 210 F., from a limited type of crude oil of high Baumé gravity. It infers that almost any oil of this viscosity range made from this crude oil will be satisfactory and any other oil made from any other crude oil will be unsatisfactory. However, the oil and automotive industries soon learned that these assumptions took in too much territory from the standpoint of actual facts and too little territory from the standpoint of source of crude oil.

In 1913 Tipper (*3*) pointed out that although these conventional laboratory tests are of value in checking uniformity of shipments and controlling refinery processes, and in some cases there is a certain amount of correlation between these tests and performance in service, "they do not demonstrate the value of oil under practical conditions." This same point has been made very many times since these early days. This is the theme of two of the most popular pieces of literature of the A.S.T.M., a paper given in 1928 by R. E. Wilson and D. P. Barnard on "The Significance of Various Tests Applied to Motor Oils" (*4*) and the A.S.T.M. publication, "Significance of Tests of Petroleum Products."

Although some of these tests may give us valuable information in regard to certain properties of an oil, it has been found by experience that the performance of an oil in service depends upon a large number of properties, and an oil is like a chain, it is no stronger than its weakest link. Consequently, although an oil may be excellent in respect to a number of tests, it may still be unsatisfactory in service due to a weakness in one or more other respects.

One of the most important properties of lubricating oil is resistance to oxidation at elevated temperatures. At the Michigan-Life Conference on Transportation, M. R. Fenske (*5*) tabulated both the usual inspection data and also a hydrocarbon type analysis on some commercial 10-W oils. These data did not include specific tests to determine resistance to oxidation, and although he listed 21 different tests on each of these oils, Prof. Fenske said,

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[1] Presented at a meeting sponsored by the A.S.T.M. Detroit District Committee, Detroit, Mich., Nov. 21, 1944, featuring a symposium on Life Testing. Another interesting paper presented by R. E. Peterson on "Relation between Life Testing and Conventional Tests of Materials" will be published in the March BULLETIN.

[2] Research Laboratories Division, General Motors Corp., Detroit, Mich.

[3] The italic numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper.

"However, giving full consideration to all the data set forth. . . there is still nothing to indicate the behavior of these oils from oxidation."

This lack of information in regard to the oxidation characteristics of oils is not due to any lack of work on oxidation tests. A number of years ago the library of The Texas Company compiled a report in which various oxidation tests that had been proposed were tabulated. Over 200 different tests were described, and since that time many additional oxidation tests have been developed. However, there are several fundamental reasons why laboratory oxidation tests may not always correlate with service. One of these reasons is found in the effects of catalysts and inhibitors.

In order to keep the laboratory test results from varying due to the catalytic effect of metals picked up from the test apparatus, many tests are made in glass, but in actual use the oil may pick up catalysts from the engine which, of course, is largely iron. In one test which we made (*6*), it was found that a certain very highly refined oil without any added oxidation inhibitor oxidized and caused very bad bearing corrosion in an engine on the road in less than 1000 miles, although the oil stood a test of 200 hr. in glass with pure oxygen at 350 F. with no appreciable effect.

At the 1939 meeting of the American Chemical Society, Downing, Holbrook, and Fuller (*7*) reported tests which showed that the method of cleaning the engine prior to making a test might greatly influence the results. They reported that much more deterioration of the oil took place in their tests when the engines were cleaned with a water solution of an alkali cleaner than when the engines were cleaned by washing with gasoline.

To determine the effect of catalysts, tests are sometimes made with the addition of various amounts of different metals or metal compounds. However, different oils are affected differently by the various metals. One oil may be very resistant to the effects of iron and very susceptible to the effects of copper. The effects of these two metals may be just reversed with another oil. Still another oil may be very resistant to both metals or greatly affected by both metals. Consequently, in studying the effects of catalysts it is desirable to run a number of tests with increasing amounts of different metals and then plot curves from the data to learn how the oils are affected by different amounts of the various metals.

Another trouble in connection with trying to correlate laboratory tests with performance in service is caused by the effects of inhibitors which may be carried over in an engine from one test to another. In some cases it has been found that oxidation did not occur in road tests with oils which showed very poor oxidation resistance in laboratory tests. Some of these results were due to the effects of inhibitors used in the previous tests in the engines not being cleaned out of the engines prior to the later tests. One of the very important factors in these tests is the proper cleaning of the test devices and actual engines so that the oil will not be rated too low due to the catalytic effect of too much metal pickup from the apparatus or the engine, or rated too high due to the carry-over of inhibitor from previous tests.

Another reason why laboratory tests do not always check with service is due to the effects of variations in the operating conditions. There are a large number of operating conditions that must be controlled in a laboratory test if it is to check with actual service. Of course, the only way in which we can be sure that a laboratory test will check with a service test is to duplicate absolutely everything in the service test, including apparatus, time, temperatures, cycle of operations, etc. However, this would mean that the laboratory test and the service test would be identical and nothing would be gained in making a laboratory test instead of simply *observing* what happens in actual service. At the meeting of the American Chemical Society in New York, September, 1944, a symposium was held on "Bench Scale Techniques." A number of the papers (*8*) given at this symposium were on life testing of engine oils, and they are worthy of very careful study by all who are interested in this subject.

Although some of these laboratory bench tests are of great value in predicting the performance of oils, the final measure of quality of an oil always must remain "performance in service." It may be objected that actual tests under service conditions are too expensive in time and money, but it is possible to make engine tests in laboratories under controlled conditions; and from the results of these laboratory engine tests, very good predictions as to performance in the various kinds of service can be made.

Of course, engine tests made in the laboratory are not "performance in service." They are simply engine tests under controlled conditions. But there is no such thing as a standardized "average performance in service." Each engine running in service is different from every other engine in service in some respect. The only real difference between a controlled engine test in the laboratory and a road test or performance in service is due to the fact that in the laboratory we have more control over the various engine and operating conditions. There is no fundamental difference between an engine operating in service and a laboratory engine test except for the fact that we usually think we know more about the conditions of a laboratory test. There is a real danger, however, in predicting from a laboratory test under known conditions as to what may happen in service under some different and unknown conditions. There is also just as much danger in predicting from a road or service test under some unknown conditions as to what will happen under all the various unknown conditions in actual service.

Laboratory engine tests have been under development for a number of years. They have been studied in the various laboratories of the oil and automotive industries and they have been studied by committees of the Society of Automotive Engineers, Coordinating Research Council, and American Society for Testing Materials. When the Army and Navy were confronted with the problem of obtaining large amounts of oil for use all over the world in a variety of engines, they both developed specifications based on both the conventional tests of viscosity, flash-point, etc., in order to classify the oils, and also on engine tests to help in predicting the performance of the oils under actual service conditions. The Navy Specification, 14-0-13 (Int), specifies among other tests:

"Diesel engine lubricating oil shall be tested for periods of not less than 300 hr. in 3 or more types of one-cylinder Diesel test engines, and for periods of not less than 500 hr. in 2 or more types of full-size Diesel engines."

This specification also states that these engine tests will

not be required on the S.A.E. 10 and S.A.E. 50 grades of Diesel oil provided evidence is submitted showing that the oils of these two grades have been approved under the U. S. Army specification, which also requires engine tests.

The U. S. Army Specification, 2-104B, like the Navy specification, requires that the oils must meet certain conventional tests and in addition a number of actual engine tests. These tests are the L-1 to L-5 tests of the C.R.C. (*9*). These various engine tests have been described in a number of papers by representatives of the U. S. Military Forces (*10*), and in these papers reports are also given of the excellent performance of these lubricants in service.

Since engine tests determine the performance of the oils only under the test conditions, and since the Army oils are used in a number of different types of engines under a wide variety of operating conditions, five different engine tests using five different kinds of engines are specified.

These tests and the operating conditions are selected on the basis of accelerated tests under the conditions which are of the greatest severity and importance in respect to the factors being tested. The first test, which is known as the L-1 Caterpillar test, is made using a single-cylinder Caterpillar engine operated at 1000 rpm. for 480 hr. with the oil at 145 F. and the jacket water at 175 F. The test is to evaluate the oil with respect to ring-sticking, wear, and detergency in a Diesel when tested at comparatively low oil temperature.

Under these test conditions, using a straight mineral oil, there will usually be considerable trouble due to varnish, ring-sticking, and carbon deposits, but if a good oil containing oxidation inhibitor and detergent is used, the piston will be clean and the rings free with little or no carbon deposits.

The L-2 Caterpillar test is made in a single-cylinder Caterpillar engine, using a special piston and injector, at 900 rpm. for 3 hr. with the oil at 140 F. and the jacket water at 175 F. The test is to evaluate the oil with respect to load-carrying and performance under accelerated run-in and high load at comparatively low oil temperature.

The L-3 Caterpillar test is made in a multi-cylinder Caterpillar engine, at 1400 rpm. for 120 hr., with the oil at 212 F. and the water at 200 F. It evaluates the oil with respect to detergency and bearing corrosion at moderate oil temperatures.

The L-4 Chevrolet test is made in a multi-cylinder Chevrolet engine, at 3150 rpm. for 36 hr., with the oil at 280 F. and the water at 200 F. It measures resistance to oxidation, bearing corrosion, and general engine cleanliness when tested at high oil temperature using gasoline containing tetraethyl lead. Under these test conditions, using a straight mineral oil that is not good in resistance to the formation of varnish and sludge, the piston and engine parts will be badly sludged and varnished, but if a good heavy-duty oil is used, the piston and engine parts will be clean. Of course, it is possible to produce an oil which is poor in resistance to oxidation but which is good under the L-4 test conditions with respect to the formation of varnish and sludge, and such an oil may give a clean engine in the L-4 test. However, the weakness of such an oil in resistance to oxidation will still be shown in this test by the poor analysis of the used oil and by corrosion of the test copper-lead bearings.

The L-5 General Motors Diesel test is made in a multi-cylinder Diesel at 2000 rpm. for 500 hr., with the oil at 230 F. and the water at 200 F. It measures ring-sticking, detergency, and bearing corrosion at moderately high oil temperature.

Since the operating conditions in most actual service are less severe than these test conditions, it follows that if the oils are satisfactory in these tests they will probably be satisfactory in actual service, provided the oil of the right classification for the service is used and provided some unusual factor or condition for which the oil is not responsible is not encountered. As an illustration, an oil might be satisfactory in all these tests and yet trouble might be experienced in a gasoline engine if the gasoline is of too poor quality with respect to gum content, volatility, or octane rating; but such difficulties should be charged to the gasoline and not to the oil. As another illustration, the oil might meet all the requirements for the S.A.E. 30 grade, and yet it might be too high in viscosity to permit starting at low temperatures if the correct classification for the engine and operating temperature should be S.A.E. 10 or diluted S.A.E. 10.

An illustration of a possible difficulty due to some unusual factor which might be overlooked in a limited amount of testing is resistance to rusting in the presence of water. It is well known that water will collect in the crankcase if an engine is operated at too low jacket and crankcase temperatures, and it is also known that the tendency of this water to cause rusting of the engine parts may be influenced by the rust-resisting properties of the crankcase oil. However, all of the engine tests L-1 to L-5, inclusive, are made at temperatures above those at which water will condense in the crankcase. At first glance it might appear that factors like this have been overlooked in the Army Specification 2-104B, but this specification contains two separate paragraphs which state that in addition to the tests that are specified, the Ordnance Department may require any additional tests that it feels are desirable. Whenever an oil company submits a lubricant that is enough different from those on which the Ordnance Department has actual service experience under a wide variety of operating conditions, such a lubricant is examined with special care and extra tests are required before a decision is made with respect to the lubricant.

Oils which have the proper chemical and physical properties so that they can meet the laboratory and engine tests given in these Army and Navy specifications are known as heavy-duty oils. They are used in all Navy Diesel engines and in all of the engines of the U. S. Ground Forces, both gasoline and Diesel. They are also used very generally by civilians in Diesel engines and in gasoline trucks and buses, but on account of the importance of these lubricants for use in the military engines, and because their manufacture requires certain critical materials, they are not available at present at the filling stations for use by civilians in passenger cars. However, after the war, when these limitations no longer are in effect, it is probable that heavy-duty oils will be used very largely in all kinds of internal combustion engines wherever the service requirements are so severe that ordinary mineral oils will not give satisfactory performance.

From this discussion it is evident that the oil and automotive industries have come a long way since the adoption of the first S.A.E. Specification for Engine Oil 35 yr.

ago. We have learned to appreciate the various factors connected with suitability of the oil and quality of the oil, and we recognize the importance of the engine and operating conditions. In standardized engine tests we have learned how to select and control most of these conditions, and in actual service we have learned much about the effects of uncontrolled variations in these conditions, and how to manufacture and select oils that will give satisfactory performance under the various service conditions. Throughout these years the men in the oil and automotive industries have learned how to cooperate in studying their mutual problems, and we have learned that although it is possible to make good predictions with respect to an oil by considering such factors as identification tests and life tests, we should not overlook certain other factors, such as the earnest desire of a company to produce products of high quality. The slogan adopted by one of the large drug companies is of equal importance when applied to lubricating oils:

"The most valuable ingredient of any product is its maker's good name."

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Testing Cordage Fibers

The critical nature of cordage fibers, so essential in the war effort, led to intensive investigation in finding a possible substitute for manila, sisal, and jute. It was important to have machines and procedures which would evaluate possible substitutions. The October *Technical News Bulletin* of the National Bureau of Standards abstracts a more extensive paper from its Journal of Research describing some of this interesting work. The following is quoted.

In the test for flexural endurance a bundle of fibers having a twist of one turn per inch is repeatedly drawn back and forth over three small pulleys located at the vertices of an isosceles right triangle. In the test for resistance to abrasion, a similarly twisted bundle of fibers is drawn back and forth against a second bundle which is twisted once around the first. This test is made in such a way that the flexing of fibers during the test is reduced to a minimum.

The procedures for selection of fibers, preparation of fiber bundles weighing 5 grains per 15 inches of length, and conditioning of test specimens are outlined. The unprocessed fibers were tested for the following characteristics: Fineness of fiber; dry and wet breaking strength and elongation; effect of elevated temperatures, continuous soaking in fresh and in salt water, alternate wetting and drying by the use of fresh or salt water, and exposure to light with intermittent spraying with water. The results of tests of six lots of abaca, nine of sisal, three of hemp, two of jute, two of henequen, one of pita floja, one of ixtle, four of sansevieria, one of palmetto, three of hemp, two of roselle, one of manzanita, one of malvita, and two of yucca are given and discussed.

Great variations were found in the characteristics of different lots and grades of one kind of fiber, and the results on different kinds frequently overlapped. No one kind of fiber was best in all respects. Abaca was the strongest of the fibers tested, but some of the lots of abaca were weaker than some lots of sisal. Henequen and sisal were more resistant to abrasion than the other fibers, and they had higher flexural endurance, but were the least resistant to exposure to light and intermittent spraying with water. Pita floja, one of the strongest fibers tested, was one of the least resistant to abrasion. Sansevieria had exceptionally good strength. Hemp and jute were very similar in all of the characteristics measured. The resistance to abrasion of all fibers tested was profoundly affected by the direction of twist in the ply relative to that in the bundle, and also by the addition of a small amount of lubricant.

Painting Steel

The latest BMS Report 102 issued by the National Bureau of Standards on the subject "Painting Steel" is the third and final report in investigations of pretreatments and paints for protecting plain and galvanized steel surfaces against corrosion. Previous reports Numbers 8 and 44 covered phases of this subject. The current paper by Wilbur C. Porter contains in condensed form results of a very extensive series of tests involving the relative durability of priming coat and topcoat paints. Accelerated laboratory and outdoor exposure tests were involved. Copies of the latest report can be obtained from the Government Printing Office at ten cents each.

A. S. T. M. "Mysteries"

Somewhere there is a gentleman we should like to meet. He must have a wonderful disposition and certainly his curiosity would not be termed insatiable. His recent action—and that's all we know about him as a basis for our concept of his qualities—was to return a 25 cent mystery book entitled "The Corpse in the Wax Works" with the statement "sent with my recent set of the Book of Standards." The peculiar thing is that no one at Headquarters has laid claim to the corpse, wax works or even the book—but somehow it did get to him.

Glass—A Summary of Its Development as an Art and as a Science[1]

By F. C. Flint[2]

Glass is a material primarily based on the silicates. It is to us almost entirely an industrial product though the material, as we now make it, still parallels in chemical and physical properties to a great extent the natural glasses. Undoubtedly our ancestors' ancestors used this material very early in their existence, for examples have been found all over the world of artifacts made from obsidian and other uncrystallized forms of the silicates. These early forms were worked cold, as in the making of knives and arrowheads. It is difficult to imagine how the first aborigine learned that by pressing with a horn on the rock he could make an arrowhead with very good ballistic characteristics. Any other uses for this material were entirely ornamental.

The stage of development that brought glass into further use did not come until fire permitted its formation into a greater variety of shapes. As Morey postulates, the first use of fire in manufacturing probably had to do with clay. Metallurgy and glass manufacturing undoubtedly developed separately, for though the technology and the science of the materials are closely related their art and fabrication are quite far apart.

A few samples of the earliest glass indicated only the formation of a glaze on the surface of a ceramic article or that a paste had been sintered together, probably about 12,000 B.C. from Asia. The oldest pure glass amulet yet found is dated at about 7000 B.C. Probably in Syria, Phoenicia or Asia Minor decorative beads and small vessels were first produced. Then, about 1500 B.C., hollow articles were built up on a core—not blown or molded. A cuneiform tablet, from about 600 B.C., was found in Nineveh—a good factory record, giving names of types of glass and formulas. The melted glass was taken out of the pot, crushed, and then remelted because the glass had not done much more than sinter and was full of cords and seeds. This method has been revived in recent years for accurate technical work.

The composition of these glasses was surprisingly close to the general composition of glasses used today—the silica about 65 per cent, the alkalies (soda and potash) from 15 per cent to 22 per cent, and the lime from 7 per cent to 15 per cent. There were always, even as now, small quantities of impurities or colorants.

The reason for this analysis being so close to present-day analyses is due to the fact that of the common elements usable in a silicate mixture—sand, soda, and lime—the eutectic makes possible the lowest temperature of melting at about these compositions. Any other effort to melt calls for more technology and control than has been available until very recent times—about the past fifty years. G. W. Morey set the limit on compositions and temperatures for crystallization only in the past fifteen years.

Glass manufacture developed first as an art. About 1200 B.C. shapes such as bowls, dishes, and cups were made in molds. It is the decorating that developed from then on that is astonishing. This consisted of adding coloring oxides of copper, cobalt, manganese, iron, and other metals. There was very little transparent glass, as transparency was not considered important. Glass blowing probably did not commence until the early part of the Christian Era.

From the beginning of the Christian Era glass quickly reached stages of intricate design and usefulness that expanded its popularity until during the Middle Ages it had spread all over Europe. Little more was done after what had been developed by the beginning of the Christian Era than to enlarge the pots, make the fire hotter, and refine the use of the blowpipe and the mold. To this should be added the development of clear glass by taking out the impurities. The development of glass cutting and the addition of lead for the production of crystal glass only helped to produce the myriad intricate forms of decorative containers that we see now in the museums. The emphasis was on workmanship and on art. We are familiar with the 12th century development of Venetian Art, the later development in Germany at Thuringia and Bohemia, the 17th century English flint glass with its development of clear glass of high index of refraction with lead and the consequent development of diamond cutting. All of this was based on craftsmanship, and the early guilds were artists as well as artisans. The volume of this glass made was not large. The common people saw little or none of it and even in our own colonial times, men lived and died without ever having seen the substance called glass. Pewter, copper, and wood supplied the vessels, and windows just weren't glazed.

American Glass Development

The first glass industry in America followed the methods developed in Europe. In Jamestown, Va., in 1609 a small pot 2 ft. long and 1 ft. wide made glass beads with which to trade with the Indians. In the next fifty years several glasshouses were started and very crude bottles, bowls, and small windowpanes were made.

During colonial days glasshouses spread up and down the coast. The workmen were frequently imported, for the art was one which had to be learned early in life. The Dutch in New Amsterdam produced the first colored glass for church decoration that was made in this country. In 1765 Henry William Stiegel started a glasshouse at Mannheim, Lancaster County, Pa. It was of short duration but developed some of the most beautiful of the old American glasses. Later the Sandwich glass was developed. The

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[1] This paper was presented at a meeting October 26, 1944, sponsored by the Pittsburgh District Committee at the Mellon Institute in Pittsburgh, Pa.

[2] Chief Chemist and Director of Research, Hazel-Atlas Glass Co., Washington, Pa.

pots were small. The formulas were secrets owned by the batch mixer or the owner of the plant, for those secrets were really valuable in the early days. Potash was literally "pot ashes." There were times when they succeeded very well in producing good clear colors and colorless glass, but still it was an art and the outstanding characteristic of the glass was not any industrial usefulness or strength but its decoration. The glasshouses were located generally at the main source of fuel—wood. When coal became common, the glasshouses began to move west, and Pittsburgh and Toledo became centers of glass making. By this time glass had become cheap enough that it was used for more utilitarian purposes, among the first, of course, being the liquor trade. Windows also became more common. When natural gas was discovered, it was in the same region in which coal was found and there was a great spread of glasshouses through the territory. This kept a number of glasshouses in the Pittsburgh, Toledo, and St. Louis districts but gradually the plants on the eastern seaboard were reduced in number. Nowadays plants are not located strictly where the fuel is found. Oil, gas, and coal are all too easily transported. It is the market for glass that is important.

During the era from the time of the Civil War to the 20th century art became less and less important. In fact, art in the United States was probably not doing too well. The ornate tableware fitted the bizarre-looking gingerbread houses that were then being built. But what was more important, various factors began to operate which slowly were to take glass out of its condition as an art and place it on a production and engineering basis.

The Art of Glass Making

The early Mesopotamian glass worker had no knowledge and few tools. His ability to produce heat was limited to what could be done with wood in a small fire-box. His knowledge of his raw materials was very limited. Limestones were often mixed with clays, and his alkalies were the impure incrustations he was able to collect. This resulted in merely melting and collecting on the end of an iron or clay rod a little of the paste from which beads and small irregular-shaped vessels were formed. In those early days the pots were no larger than a quart jar but they gradually grew until finally there was sufficient glass in the pots so that by the beginning of the Christian Era they could use the blowpipe. By this method the glass was gathered on the end of an iron tube and air blown by mouth into it, producing a bubble which was shaped by holding the bubble inside of a mold. That basic fact, 2000 years old, is still the most important fact in the glass works of today. It rates in glass making with the invention of the wheel in engineering. Glass works welled up where a new civilization was being developed and each time new tricks were learned. The mold in the early days of wood was improved—later to be made of iron, and in another 2000 years to be air-cooled. The methods of working the pasty glass to produce knobs and handles on vases grew through the medieval days. Decorations by added minerals for colors, by overlaying layers and applied threads were marvels in the manual skill of human hands, still being done with the simplest of tools—a pair of shears, a pair of pincers, and a few paddles and sticks, and with little improvement on the old art, as it grew through the Dark Ages and moved from Phoenicia to Venice, to Thuringia, to England, and to America. The pots became a little larger, the colors a little clearer but the essence was still the same. It was an art. There was a mystery to it which was maintained by the Guilds.

Modern Machine Development:

Modern machine development may possibly be said to have started about 1825. Then a very simple, crude, hand-operated metal piece of equipment was placed in front of the opening in the furnace. A man gathered the glass on a punty (short for "pontil," a tribute to the Belgian and French workers who came to this country) and dropped it into a mold, cutting it off with a pair of shears. A plunger dropped into the mold to form the article. This increased leverage and the use of metal began a series of events which has been going on for over 100 years. This was the second large step in the development of glass because these simple machines have grown into the intricate and elaborate machines which are producing bottles today by the millions. Also, since these machines, not being human, could not vary the pressure or the blow with the difference in the glass, they demanded better control of the raw materials and of the temperature. The side-lever press and the so-called "three-boy" then "two-boy" then "no-boy" machines were still advertised in trade journals only twenty years ago. Those first machines produced no faster than a human hand or mouth but they produced more uniform ware. One of the handicaps in the early development was the lack of machine tools. We now take for granted the use of pipe and machined gears. In the early days crudely formed castings with hand-chipped surfaces were about all that were obtainable. When machine parts were available the speed of the machines became such that where a man would form one or two pieces a minute, he can now produce sixty a minute while he is smoking a cigarette. One of the later developments in our own generation was the window glass. Formerly it was nothing more than the side of a large bottle blown by mouth, cut and laid flat in a warming oven; or a portion of the bottom of a flat bottle, the center of which made those bull's-eyes which are now imitated in the decoration. Now all window glass in this country is drawn flat fully automatically, marvelously controlled and of much better quality than the old handmade glass. Even plate glass, which is a development of recent times, has succumbed to machine development. Formerly it was hand-ground, then with a crude individual machine, and it is now continuously ground and polished.

All of this machine development has been possible partly because of the increase in knowledge of mechanics. The first work on machines was done by glass blowers of an inventive turn of mind, aided by operator owners of the small plants who envisioned the possibility of reducing the cost of their wares—for glass has always been purely a commercial product.

Development of the Science of Glass

These machines called for greater control. This control grew up slowly even in the Middle Ages and in the 18th century, and is a part of the development of the chemical industry. Potash became more uniform. Soda ash, once

made by the LeBlanc method, was full of salt cake and variable in strength. It was improved with the Solvay method. The British, when they were endeavoring to produce fine tableware, found that flint pebbles made a cleaner, more transparent glass.

But the greatest technical advance came through the development of glass for optical purposes. There had been no general knowledge of the index of refraction and dispersion of light passing through the glasses used in microscopes and telescopes until Schott of Jena worked it out in the 1880's, only sixty years ago.

Schott's work was the basis on which Germany built her world trade in optical instruments. It was well deserved but very soon followed by French and British interests who not only took up the improvements Schott had developed but made their own contributions. This knowledge was limited at first to a better understanding of how to obtain clear, bubble-free, cord-free glass in a pot and to be able to repeat from one melt to another the index of refraction and dispersion which calculation had shown was desired. The knowledge of the chemicals progressed along conventional lines in all countries, not only for optical glass but for the more ordinary articles. The weighing of the batch became more of a precision operation. Even then, as late as twenty years ago, river sand was being used for melting bulk glass and no corrections made for the variable impurities. Alumina, a valuable constituent of glass, now bought chiefly in the form of feldspar, was not recognized. The Thuringian Glass Works made a reputation for laboratory glass because for some unknown reason the Thuringian sand produced a glassware that would not scum on reheating in forming the laboratory ware. It was later found that the small amount of alumina it contained produced this effect. It was only two generations ago that students in college laboratories (there were practically no plant laboratories) repaired the bottom of broken test tubes themselves. Glassware just was not common. During the last war the Society of Glass Technology was organized in England and W. E. S. Turner is still its head. The first papers described efforts to stabilize the glass. In 1918 the Glass Division of the American Ceramic Society was organized and finally in 1937 Committee C-14 on Glass and Glass Products of the A.S.T.M. was brought into being. During these years the development gradually changed from studies of the raw materials and control methods to more fundamental work.

The change took different paths in different countries. In Europe there was more inclination for the institutes to do the studying. The Kaiser Wilhelm Institute began to work on fundamentals. In England, the Society of Glass Technology, at the University of Sheffield, produced a volume of work. The British Physical Institute and a few company laboratories, some having affiliations in this country, began in the past 25 years to produce results. In this country little was thought of glass from a scientific standpoint until the beginning of the last war, when we found how very dependent on Germany we had become for optical glass. The two chief agencies of scientific progress at that time were the Geophysical Laboratory and the National Bureau of Standards. The Geophysical Laboratory, which had not done any work on commercial glass, did have the background and knowledge of silicates and a trained personnel who were able to contribute quickly to the then great need of the war. The Bureau of Standards opened a laboratory in the Pittsburgh district and developed production methods and a background which is still recognized. The only company that had taken up a technical and scientific attitude on glass at that time was Corning, just beginning to reach into heat-resisting glass with Pyrex and a better knowledge of light transmission for signal glass.

Comparison of European and American Scientific Methods

Between the last war and this one in all countries corporation laboratories began to be developed. Some went into more fundamental work than others and profited accordingly. In this country, without having any central laboratory guiding it, we were able to develop many more lines of thought than most of the other countries. The University of Illinois took up practical aspects of glass melting. The Mineral Industries Department of Pennsylvania State College developed work along theoretical lines. The College of Ceramics at Alfred, N. Y., developed personnel. The Bureau of Standards, by a continuous appropriation to insure a supply of optical glass for the Army and Navy, continued itsstudies; and theGeophysical Laboratory worked more on the glassy phase and crystallization of compounds in the region closer to commercial glasses than ever before. Massachusetts Institute of Technology and the University of Chicago began to contribute knowledge on the molecular structure. Mellon Institute had fellowships. This and many others developed a multifaceted approach which, combined with the unique engineering attitude in America, has developed glass as a business and as a science to the fore of any other political unit in the world.

Seaman and Martin's work on furnaces developed the ability to reheat the incoming air and produced higher temperatures in larger units than had heretofore been possible. This meant the development of the open-hearth steel furnace and the glass tank, both so nearly alike that one would have to look carefully to be sure which furnace he was examining. Natural gas helped to produce the uniformity so desired and enlarged the tanks until now 100-ton tanks are common. I mention this with the machine development for rapid, continuous, uniform, high-speed production of containers and the continuous strip production of window glass at the rate of three miles a day per machine and the continuous grinding of plate glass for automobiles as a basis for developing the need of more science. Along with these bulk glass productions and their improvements have come the specialty glasses. In the old days the college textbooks mentioned hard and soft glass. There was an ill-defined difference between the two even imperfectly understood by the laboratory men who worked the tubing and made the apparatus. Schott had improved this to some extent, then Pyrex came after a real study of the influence of the ingredients in the glass. I am giving you these developments somewhat separately, but the beginnings of the special glass were growing while the bulk glasses were being improved. Along with these developments during the past fifteen years before World War II have been advances in the fundamental scientific knowledge of glass on which may be hung a good portion of the very recent new ideas.

Progress Between World Wars I and II

Glass is a sort of a least common denominator for the silicate industry. It is the bond between the particles of most all of the ceramic products. Glass itself is no different from the magma of the original earth's crust which has cooled without crystallizing. The modern glass furnace is nothing more than a volcano in a small and controlled condition, and the machine only blows a bubble of the glass and controls its shape. This was what has brought the work of the Geophysical Laboratory into commercial contact and it is this which has made the commercial laboratory turn to such work on fundamental science as Morey's phase rule of the silicates in which we have learned what compositions to use in order to keep away from the liability of crystallization. In 1916 A. L. Feild, of the U. S. Bureau of Mines, developed a viscosimeter for the study of blast-furnace slags. This and other methods have been improved until today glass viscosities are commonly determined with an accuracy that is astonishing. It is the peculiarity of gradual viscosity change with temperature that makes glass manufacture possible and, at the same time, determines the method of its use. Glass is a peculiar substance. Being generally transparent, it has been difficult to know just what to make of it. Its physical properties of hardness, light transmission, and index of refraction told little of its composition for a long time. The analysis was given for years following the old mineralogists' formulation by oxides.

Then Zachariasen in Chicago and Warren at Massachusetts Institute of Technology began to work on the X-ray patterns of glass, searching for the molecular structure, until now we have a pretty good picture of the arrangement of the atoms of silicon and oxygen, the reason for the tight bonding of the silicon and the relative position of the various elements as they find themselves either in the interstices or in the structure of the lattice itself. This important knowledge is backing up very much the search for the reasons for the physical properties which in the past twenty years have become more accurately known. The first efforts were in finding causes for the changes in the curves of expansion as found by Tool at the Bureau of Standards, then in electrical properties and the effect of the heat history on the glass.

At the same time that this was going on, knowledge was being gained on the applied physics and chemistry of the material. Glass as a material can have greater tensile strength than iron, but it has always been rated as more unreliable. Tensile strengths were obtained much beyond anything the metals could produce, but the factor of safety from an engineering standpoint had to be so large that for all practical purposes the glass was weaker than steel. Now knowledge of the tensile and compressive strength is based on knowledge of molecular arrangement and surface condition. The result has been a flood of work on heat treatment of glass that protects it from breakage, redesign of parts that parallels the work done on airplane structures, and surface treatment to condition the molecular layer on the outside. All of this has been done by many individual laboratories; window glass companies taking advantage of the fundamental knowledge in their own work on flat glass, bottle companies for the making of more efficient containers, and specialty companies for the production of the new reaches of this most ancient material. One of the first advances that was made in the study of glass was the application of the polariscope, known a century ago but since the last war applied to the examination of glass in almost every factory. It led to a knowledge of the location of strain and resulted in changes in design and improvement of manufacturing technique. All this has led to what we are now primarily interested in, the new places glass has gone as a commercial product. These places are quite numerous and have been dramatically told, particularly in the Sunday Supplement section of the newspapers. It has made them look more revolutionary than they are. The advertising man has not been slow to take advantage of them.

New Developments in Glass Making

Glass product development is not an unconnected assembly of isolated phenomena which the announcements would imply. These developments can readily be classified in their engineering, physical, and chemical category. These overlap somewhat but, based on the history which I have given, they can be put in their proper place and their possibilities of use can be figured. Glass has undoubtedly reached very near its peak of artisans' development because this went on for a great many centuries and under conditions in which there was no competition to the artistry of manual manipulation.

Engineering development will naturally progress more rapidly for a while than the more truly scientific physical and chemical development because there is a longer time of growth in engineering and we have the machinery and equipment which can give us larger sizes, higher speeds, and better quality of the items which we are now using.

We have covered the fact that the physics and chemistry of glass have been imperfectly known for a great many years, but only very recently has the knowledge been general enough or deep enough to give us the advances which are now beginning to unfold. Twenty-five years is a short time in which to obtain the fruit of such work as on the molecular structure in a material.

Engineering Developments in Glass:

Building glass has come in for a certain amount of attention, first with the hollow blocks with a partial vacuum in them to help insulation and with flutings to influence the direction of light. Now there are the porous insulating blocks, taking up the subject of insulation from an entirely different angle. This, too, is a problem that had been worked on years ago with blast-furnace slag. Also there has been a lot of pipe-dreaming about colored plate glass walls reflecting varicolored light at different times of the day, and the sliding of panels of polarized glass back and forth to produce opaque or transparent walls. There have been ideas about heating by reflection the room from the walls and the floor, which would certainly make for more comfortable living. All these have two factors which must be satisfied. Are they technically possible? Are they economically sound? It is pleasant to pipe-dream, but only in very expensive installations such as cocktail lounges will some of these things be seen for a while—where for a particular installation the expense need not be considered.

With modern insulation, the windows of a house repre-

sent an increasing factor in heat loss. Double-glazed windows have an advantage in giving light visibility, ventilation, and at the same time prevent heat loss, cold air down drafts, and sweating.

Glass wool and glass thread are other old products which modern science and technology have expanded magnificently. Anyone who has ever worked glass knows of the tails of the gathering that collect on the edge of a pot. It looks like long threads of white wool. It is very much like the tails, similarly caused, that sometimes are seen in a candy factory. For years in this country there have been innumerable small plants making a crude wool out of rock whose composition would produce a crude kind of glass. Twenty years ago there were probably eighty of such plants but their total volume of business was too small to be of any note. The modern knowledge of physics and engineering has produced a cleaner, properly sized material in tremendous volumes which is a much more satisfactory insulating material, with all the resistance that the silicate has to chemical attack. By controlling the size of the threads, textiles have been produced, insulating materials improved, and now even the field of plastics has been entered in which the glass used as a filler is adding its strength to the plastic.

Glass jewels were common in the ancient days of the Indian Empire when people were not too particular about looking into the specific gravity, index of refraction, hardness, and cost of the jewels. It did not mean so much then as it does now to produce glass jewels. Instrument bearings need sapphire-hardness and a hole drilled to a hundred-thousandth of an inch, and production in the millions.

Physical Developments in Glass:

A good many centuries ago Prince Rupert demonstrated the peculiar phenomenon of a drop of glass rapidly cooled in water that broke with great difficulty and then shattered into "a million pieces." When it was finally learned that this strength was due to the compression of the surface, it was even then a long time before the engineering facilities were obtained with which to take advantage of this tremendous increase in strength. If ordinary glass will break at a tension of 10,000 psi. and a compression strain can be put on the surface of 90,000 psi., it results in a glass which will not break until the surface tension exceeds 100,000 psi. All this is predicated on the knowledge that it is the surface which gives way first. This started in a small way as boiler gage glasses, then as a method of making automobile window glass better and cheaper than the laminated glass. It called for a knowledge of the exact amount of compression that was desired so that the particles from the break would be of the right size. This was comparatively simple on flat glass, but when they got into bomber noses so accurately made that there was no distortion of vision, it was a real engineering job. Then the idea worked over into tumblers, tableware, and finally even has been tried out in furniture and doors. I am not inclined to believe that it is going to revolutionize the furniture industry, but it is interesting to see what a good, heavy plate of glass will stand when it is properly treated.

We have the high index of refraction glasses developed by Morey, using compositions heretofore impossible because of our lack of knowledge of the relation between the phase rule, viscosity, and time. In optics the high index of refraction is often accompanied by a high dispersion of the various regions of the spectrum. Compositions of optical glass heretofore have been such that in order to correct for this, multicomponent lenses had to be made. Some of these new glasses will simplify the use of and extend the field of light which it is possible to use.

Chemical Developments in Glass:

One of the first of the developments of glass along lines other than customary containers or windows was at Corning in the development of a heat-resistant glass. This again was not a new idea. For a long time compositions had been produced that were of lower coefficient of expansion and slightly more resistant to chemical attack. By taking up the problem from a scientific rather than the artisans' angle, the Pyrex glasses have been produced with which we are familiar in laboratory ware, cooking utensils, and now in large industrial applications. The advantages are obvious. The transparency and neutral nature of the glass extend greatly the range of its usefulness. These glasses have reached into compositions of such low coefficient of expansion and toughness, combined with a compressed surface, that they can be used directly over flame.

New work has been done on the chemical surface resistance of glass. First, elaborate studies evaluated this. Then the composition of the glass was changed so that it was much more resistant to this attack. The first work had to do with neutralizing the tendency of the surface to dissolve in water and chemicals. Committee C-14 on Glass and Glass Products has standards set up for these tests. Window glass was treated with acid to slow down alkali attack. Then the glass was treated on the surface with sulfur, thus allowing the use of an ordinary glass for chemical resistance. Then came the work of Jones and others in treating the surface of the glass with a molecular layer of another material, changing the index of refraction so that reflection was reduced, a chemical treatment for an optical job. This has given glass, which formerly transmitted only between 90 and 95 per cent of incident light because of surface reflection, the ability to transmit 95 to 99 per cent. All this has been used to good advantage in the making of microscopes and binoculars. It can later be used on larger surfaces. It is a most valuable addition to optics.

One of the spectacular developments in glass has been Corning's work on what is called Vycor. Taking advantage of the knowledge recently gained of the several liquid phases of glass, a short cut has been found to what is almost fused quartz. Instead of trying to melt quartz at approximately 3100 F. glass of the proper composition is melted, formed into articles, and then the alkalies leached out. This is just the reverse of what we endeavor to do with most glasses. We try to prevent the leaching out of the alkalies, with its consequent interference with substances in contact with the surface. When a very high percentage of these alkalies is leached out, the article is then reheated until the glass shrinks so that the article becomes smaller. But now, instead of glass with only a reasonably low coefficient of expansion, it is primarily quartz glass. It is as if a brass article were so treated as to

extract most of the zinc and other constituents, leaving the copper sponge, which would later be heated to cause it to shrink until the metal became continuous.

The last and most spectacular development in glass, based on its science entirely, has been the development of the silicons. These are organosilicon or they may be called inorganic organics. It is to be recalled that silicon and carbon are next-door neighbors in Group 4 of the Periodic Classification of the Elements. They are next-door neighbors but they have seldom spoken to each other. They have a good many characteristics in common, which indicates that they even belong to the same family. Each element went its own way over the years. Carbon developed into what we call organic chemistry because of its ability to make long chain and ring reactions. We might say it is more prolific. We are familiar with its great development even to the modern plastics, oils, and, in conjunction with other elements, the proteins.

Silicon, on the other hand, though it developed the same family characteristic of ability to form large compounds making possible the multitudinous rocks and minerals, never seemed more than rarely to meet with its relative, carbon. This is due to two things. The nature of the silicon-oxygen relation is such that it does not become fluid and reactable except at extremely high temperatures, at which carbon compounds disintegrate. Likewise the characteristic of silica and silicates seemed to be generally an insolubility in water, the common low-temperature medium for chemical reaction. But as Kipling might have said, "Heat is heat and wet is wet and never the twain shall meet." However, Kipling did not take into account the catalyzing influence of commerce even in his original. So, too, when commercial possibilities invited attention to this apparent incompatibility, silicon was introduced to its relative. We now have as a result a series of compounds made by introducing silicon into organics, which make possible oils with the same general properties of organic oils but modified by the closer packing characteristic of the silicon atom so that they withstand higher temperatures, and we have plastics with some of the characteristics of silicon introduced not as a glass but as intimate atomic parts of the molecular structure making possible variations in heat resistance, viscosity, and electrical resistivity and insulating characteristics which throw open a whole new world of possibilities.

Once chemistry was a definite field of science, and physics lived in its own sphere. Then came physical chemistry. Once inorganic chemistry was a definite field and organic another. Glass was defined as inorganic and plastics as organic. Research is no respecter of tradition and the few glimpses we have had of the things glass has done are probably only preliminary to much greater developments in the future.

1944 Cast Metals Handbook

The extensively revised (1944) edition of the A.F.A. Cast Metals Handbook deals exclusively with the engineering properties of cast metals and has been prepared especially for those who design metal parts and who specify or purchase cast metals. The book includes considerable information of value to designers of castings, showing examples of specific structures where redesigning has made possible a greatly improved product. A section is devoted to the significance of such tests as resistance to fracture, creep strength, hardness, static and dynamic ductility, corrosion fatigue, wear, etc.

Separate sections deal with steel, malleable iron, cast iron, and non-ferrous alloys, all technical data included having been brought up to date from the 1941 book. Specifications (A.S.T.M., Federal, Navy, S.A.E., A.M.S., and Bureau of Ships) are shown for both ferrous and non-ferrous products.

The technical data given were prepared and approved by committees of the American Foundrymen's Association, composed of many outstanding authorities on cast metals and foundry practices. Extensive bibliographies are included for each of the various cast metals sections, with the many references to both American and foreign foundry practices adding to the value of the book for research purposes.

The Handbook has been recognized as a standard treatise on the engineering usefulness of all cast metals, and as such should be of interest and value to all mechanical, product, and designing engineers.

Comprising 745 pages, with 260 illustrations and over 200 tables, the book can be obtained from the A.F.A. Headquarters, 222 West Adams St., Chicago 6, Ill., at $6.00 per copy.

Joint Army and Navy Specifications

The October issue of *Industrial Standardization*, the news medium of the American Standards Association, 70 E. 45th St., New York 17, N. Y., includes an interesting article by Colonel B. L. Neis, Quartermaster Corps, War Department Chairman of the Joint Army-Navy Committee on Specifications, describing the mechanics of how the A-N specifications are developed. A large number of these specifications have been issued covering numerous combat items, electronic equipment, Quartermaster materials and various raw materials, both metals and non-metals.

The article points out that while the joint committee was established by a directive in December, 1942, actually there have been cooperative developments and joint utilization of many items for a considerable number of years.

Steadier Jobs

"My goal for America is a high level of production, of employment, and of wages. You can't build a steady economic structure on the quaking foundation of irregular jobs. And never forget that our economic system and its results must withstand continuous comparison with others.

"There is no snake oil that will cure our unemployment problem. What I am commending to you is a willingness to look at it with an open mind. Let us avoid embracing the new just because it is new. But let us not be afraid of new ideas. Americans have been pioneers for 300 years. We know that the pioneerspirit is not dead among us!"

From "Steadier Jobs" by Eric A. Johnston, President, Chamber of Commerce of the United States, presented before a joint meeting of the Milwaukee Association of Commerce and the Wisconsin State Chamber of Commerce at Milwaukee.

A New Machine for Measuring Wear Resistance of Walkway Materials[1]

By A. W. Cizek, Jr.,[2] D. H. Kallas,[2] and H. Nestlen[2]

Resistance to wear is one of the most important functional properties of walkway materials and is the most difficult to evaluate by laboratory methods. The authors have attempted to develop a laboratory machine and method with the view that rapid and duplicable determination of wear resistance will be of great commercial and scientific value and will lead to the development of more durable walkway materials.

Wear resistance may be defined as the ability of a material to resist the progressive wearing away of its exposed surface by rubbing action. Machines incorporating various mechanical actions to produce wear have yielded satisfactory results and are currently in use on certain phases of the problem of wear resistance. In general, however, it has been difficult to build equipment which would give satisfactory comparative data for the evaluation of materials of different composition.

The principal difficulty in the development of a suitable machine lies in the fact that wear is not caused by one factor, but is the effect of many variable factors such as impact, sliding, scuffing, and rubbing, all in the presence of an abrasive. The problem of wear becomes even more involved when it is noted that some of these factors may be present in one case and entirely absent in another. It is evident, therefore, that wear resistance is a complex property and varies according to the particular service to which a material is subjected. Any machine which attempts to measure indiscriminately the wear resistance of all kinds of materials subjected to all conditions of wear is based on the premise that wear resistance is independent of the factors involved. This is an erroneous supposition and can only lead to false conclusions.

In view of the foregoing, the authors have limited themselves to the development of a machine which will be primarily a wear test machine for determining the resistance of walkway materials to wear. Of course, as frequently happens, apparatus developed for one purpose can be and is successfully used for related work, and it is neither the intention nor the desire of the authors to restrict the application of this apparatus. However, as has been indicated earlier in this paper, it is not considered that the solution of the wear resistance problem is limited to one method or one type of apparatus. The applicability of the authors' machine is entirely dependent on the similarity of the factors influencing wear with those which were investigated during the development of the machine described herein.

The first step in the development of a suitable apparatus was, by necessity, a rational analysis of the conditions of wear which were to be expected on walkway materials. As it was recognized that wear resistance was a complex property and would have to be investigated for the specific condition in mind, a study of the wear of walkway materials was made. The presence of the following basic factors was found to be essential for a satisfactory solution of the problem.

1. Sliding of the test surface against another surface.
2. Impact of the test surface with another surface.
3. Continual reversal of direction of motion between test surface and another surface.
4. The presence of abrasive particles between the test surface and another surface.
5. Random motion of the abrasive particles.

The above factors having been established, the analysis of the problem could now be continued to its conclusion. However, although the rational analysis outlined above may have been extended further to include quantitative criteria limiting the above factors, it was considered that a continuation of the analysis on an empirical rather than

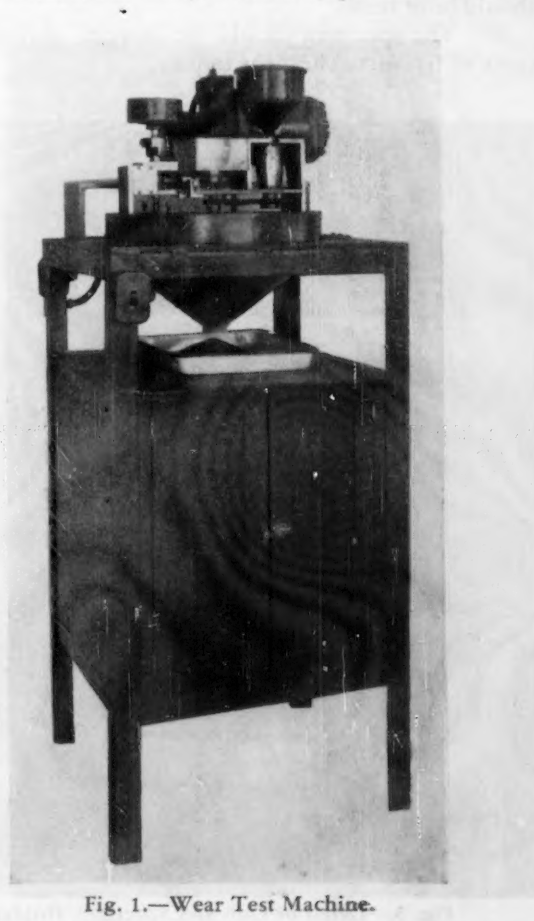


Fig. 1.—Wear Test Machine.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

[2] Materials Engineers, Material Lab., U. S. Navy Yard, New York.

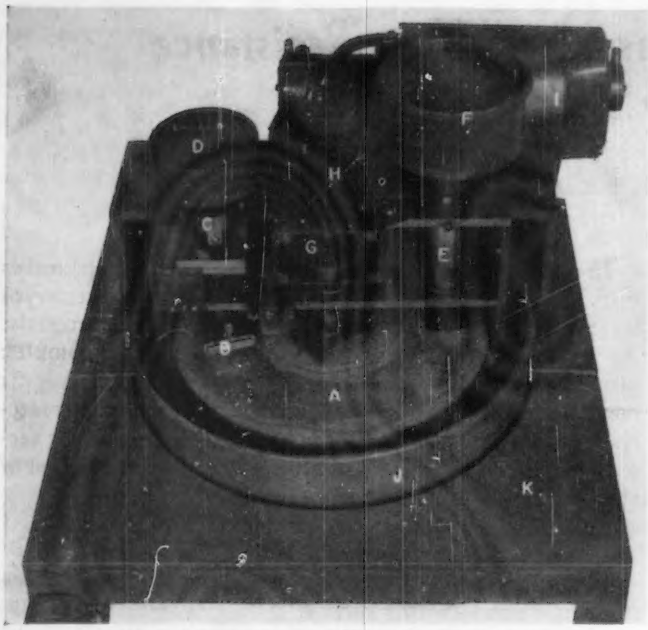


Fig. 2.—Detail View of Wear Test Machine.

a rational basis would be more desirable, particularly from the viewpoint of machine design and expedience. On the basis of preliminary experiment and test data, it was therefore decided that the factors enumerated above should be modified as follows:

(*a*) The surface against which the test material moves should be of steel.

(*b*) The specimen should be dropped through a distance of $^1/_{16}$ in. to effect the impact.

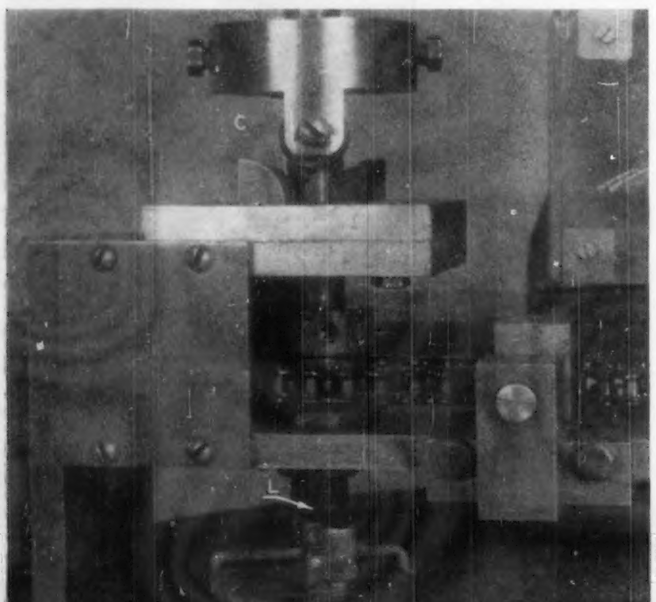


Fig. 3.—Detail of Cam and Specimen Holder.

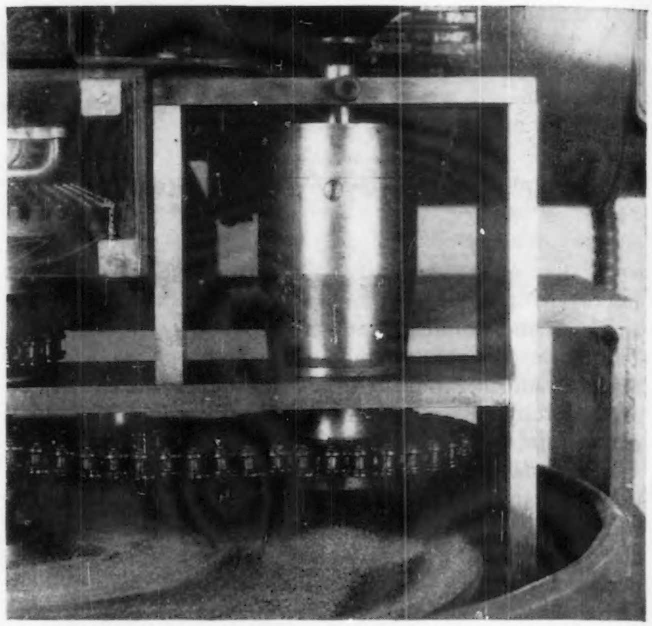


Fig. 4.—Detail of Distributor of Abrasive Grit.

(*c*) The abrasive particles should be of the same material and grit size.

(*d*) The abrasive particles should be continually replaced at a constant rate.

(*e*) The abrasive particles should be cleaned and screened before being used.

(*f*) The specimen test area should be a 2 by 3-in. rectangle.

(*g*) The total load on the specimen should be 10 lb.

(*h*) The relative velocity between the test material and surface should be reasonably low to avoid heating effects.

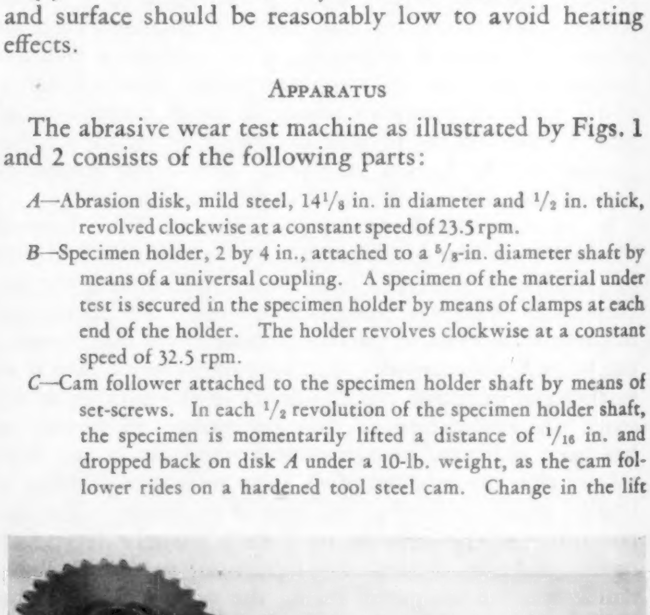
Apparatus

The abrasive wear test machine as illustrated by Figs. 1 and 2 consists of the following parts:

A—Abrasion disk, mild steel, $14^1/_8$ in. in diameter and $^1/_2$ in. thick, revolved clockwise at a constant speed of 23.5 rpm.

B—Specimen holder, 2 by 4 in., attached to a $^5/_8$-in. diameter shaft by means of a universal coupling. A specimen of the material under test is secured in the specimen holder by means of clamps at each end of the holder. The holder revolves clockwise at a constant speed of 32.5 rpm.

C—Cam follower attached to the specimen holder shaft by means of set-screws. In each $^1/_2$ revolution of the specimen holder shaft, the specimen is momentarily lifted a distance of $^1/_{16}$ in. and dropped back on disk *A* under a 10-lb. weight, as the cam follower rides on a hardened tool steel cam. Change in the lift



a *b* *c* *d*

Fig. 5.—Disassembled Distributor of Abrasive Grit.

due to wear of the specimen is compensated by adjustment of the cam follower at regular intervals, so that the lift is maintained at a practically constant distance.

D—Weight, 10 lb. acting on specimen.

E—Distributor for abrasive grits, as shown in detail by Figs. 4 and 5, consists of the following parts:

- *a*—Grit distributor sprocket.
- *b*—Grit distributor casing.
- *c*—Diaphragm perforated with eight $^3/_{64}$-in. diameter holes, centered on a $1^5/_8$-in. diameter pitch circle.
- *d*—Grit conveying tube and agitator.

The grit flows by gravity from the hopper *F* through a $^{13}/_{64}$-in. inside diameter conveying tube into the center of the distribution chamber. The agitator feeds the grit from the center of the distribution chamber outward to the holes in the perforated diaphragm. The grit then falls through the holes to disk *A* in the path of the test specimen, at a rate of approximately 44 g. per min. It is notable that the grit conveying tube and agitator are stationary, and the grit distributor casing is revolved by sprocket *d* at a constant speed of 9 rpm.

F—Hopper for feeding abrasive grit.

G—Bevel drive gear.

H—Predetermining revolution counter and switch.

I—$^1/_3$-hp. compound wound d. c. motor.

J—Hopper for collecting used abrasive grit.

K—Steel frame.

The abrasive grit consists of No. 80 aluminum oxide, which is washed, dried, and screened before being placed into the hopper *F*. The size of the test specimen is 2 by 3 in., and the thickness and other details vary according to materials, as follows:

(*a*) Wood and mastic walkway materials.—Specimen $^1/_4$ in. thick attached to a 2 by 4 by $^1/_8$-in. thick steel plate, leaving $^1/_2$ in. of plate exposed at each end.

(*b*) Light-weight walkway materials.—The coating is troweled or sprayed to a thickness of approximately $^1/_{32}$ in. on a 2 by 3-in. raised portion of a 2 by 4 by $^1/_4$-in. thick steel plate, leaving $^1/_2$ in. of plate exposed at each end.

(*c*) Linoleum.—The linoleum is attached with linoleum cement to a 2 by 3-in. raised portion of a 2 by 4 by $^1/_4$-in. thick steel plate leaving $^1/_2$ in. of plate exposed at each end.

TABLE I.—TEAK WOOD.

	Specimen	Wear, in.		
Number of revolutions.....		0 to 500	500 to 1000	1000 to 1500
First Operator.....	No. 1	0.0414	0.0410	0.0418
	No. 2	0.0379	0.0395	0.0388
	No. 3	0.0381	0.0368	0.0402
	No. 4	0.0407	0.0410	0.0393
Second Operator...	No. 5	0.0397	0.0448	0.0454
	No. 6	0.0409	0.0435	0.0415
	No. 7	0.0420	0.0416	0.0439
	No. 8	0.0428	0.0359	0.0364
Third Operator....	No. 9	0.0407	0.0412	0.0430
	No. 10	0.0376	0.0340	0.0322
	No. 11	0.0403	0.0392	0.0399
	No. 12	0.0443	0.0456	0.0446
Fourth Operator...	No. 13	0.0426	0.0439	0.0436
	No. 14	0.0505	0.0511	0.0500
	No. 15	0.0350	0.0355	0.0342
	No. 16	0.0519	0.0515	0.0471
Fifth Operator.....	No. 17	0.0450	0.0445	0.0450
	No. 18	0.0433	0.0450	0.0448
	No. 19	0.0425	0.0431	0.0449
	No. 20	0.0519	0.0507	0.0531
General average..........		0.0425	0.0425	0.0425
Average total amount of wear..........0.1275				
Standard deviation........		0.0044	0.0049	0.0049
Final average[a]............		0.0417	0.0426	0.0429
Final average total amount of wear.....0.1272				
Maximum..............		0.0519	0.0515	0.0531
Minimum..............		0.0350	0.0340	0.0322
Number of readings omitted by means of the first standard deviation to determine the final average		6	7	5

[a] Final average determined by elimination of high and low readings with first standard deviation.

The specimen is clamped to the $^1/_2$-in. wide exposed surface of the specimen holder *B* which is connected to the $^5/_8$-in. diameter shaft by means of the universal coupling *L* (see Fig. 3).

Method of Test

Tests were made in the above machine to determine the rate of wear on 20 specimens of each of the following walkway materials, obtained from Naval stores:

Teak wood.
Battleship linoleum (Navy Dept. Spec. LLL-L-351a).
Light-weight walkway material (Navy Dept. Spec. 52D9).

NOTE.—The light-weight walkway material consists primarily of a resinous vehicle with pigments and a considerable proportion of fine abrasive particles employed to give the coating anti-slip and wear-resistant properties. The material is furnished in consistencies suitable for application either by troweling or by spraying.

The wear was determined by measuring the difference in thickness of the specimen before and after a given number of revolutions of disk *A* on the wear test machine. The teak wood and linoleum were tested for a total of 1500 revolutions, thickness measurements being taken after each 500 revolutions. The light-weight walkway material was tested for a total of 100 revolutions, thickness measurements being taken after each 25 revolutions. The thickness of the specimens tested was taken as the average of 12 measurements made by means of a dial thickness gage at locations on a template used for all specimens. Tests were made only on the materials "as received," that is, without exposure to any conditions of aging and with specimen and disk in a dry condition. In order to take account of personal element in conducting the tests, each of five individuals tested a separate lot of four specimens of each type of walkway material.

Results of Test

The results of test are given in Tables I, II, and III, and the plotted averages are shown in Figs. 6 and 7.

TABLE II.—LINOLEUM.

	Specimen	Wear, in.		
Number of revolutions....		0 to 500	500 to 1000	1000 to 1500
First Operator.....	No. 1	0.0073	0.0041	0.0073
	No. 2	0.0074	0.0055	0.0060
	No. 3	0.0058	0.0065	0.0049
	No. 4	0.0061	0.0065	0.0045
Second Operator...	No. 5	0.0121	0.0068	0.0022
	No. 6	0.0018	0.0098	0.0067
	No. 7	0.0064	0.0051	0.0048
	No. 8	0.0062	0.0058	0.0050
Third Operator....	No. 9	0.0106	0.0076	0.0059
	No. 10	0.0053	0.0051	0.0061
	No. 11	0.0063	0.0050	0.0034
	No. 12	0.0060	0.0059	0.0008
Fourth Operator...	No. 13	0.0075	0.0044	0.0035
	No. 14	0.0081	0.0054	0.0046
	No. 15	0.0029	0.0069	0.0049
	No. 16	0.0020	0.0060	0.0050
Fifth Operator.....	No. 17	0.0041	0.0044	0.0065
	No. 18	0.0069	0.0041	0.0046
	No. 19	0.0075	0.0059	0.0053
	No. 20	0.0060	0.0064	0.0052
General average..........		0.0063	0.0059	0.0049
Average total amount of wear..........0.0171				
Standard deviation........		0.0024	0.0013	0.0014
Final average[a]............		0.0065	0.0059	0.0052
Final average total amount of wear.....0.0176				
Maximum..............		0.0121	0.0096	0.0073
Minimum..............		0.0018	0.0041	0.0022
Number of readings omitted by means of the first standard deviation to determine the final average		5	6	5

[a] Final average determined by elimination of high and low readings with first standard deviation.

TABLE III.—LIGHT-WEIGHT WALKWAY MATERIAL.

	Specimen	Wear, in.			
Number of revolutions..		0 to 25	25 to 50	50 to 75	75 to 100
First Operator...	No. 1	0.0123	0.0041	0.0024	0.0017
	No. 2	0.0138	0.0046	0.0028	0.0014
	No. 3	0.0127	0.0041	0.0021	0.0022
	No. 4	0.0135	0.0036	0.0022	0.0012
Second Operator.	No. 5	0.0100	0.0040	0.0033	0.0035
	No. 6	0.0129	0.0028	0.0025	0.0024
	No. 7	0.0131	0.0026	0.0033	0.0021
	No. 8	0.0136	0.0048	0.0026	0.0023
Third Operator..	No. 9	0.0122	0.0030	0.0029	0.0024
	No. 10	0.0110	0.0040	0.0030	0.0022
	No. 11	0.0138	0.0035	0.0032	0.0026
	No. 12	0.0096	0.0061	0.0023	0.0028
Fourth Operator.	No. 13	0.0121	0.0042	0.0024	0.0015
	No. 14	0.0128	0.0035	0.0031	0.0006
	No. 15	0.0141	0.0042	0.0049	0.0035
	No. 16	0.0135	0.0034	0.0019	0.0013
Fifth Operator...	No. 17	0.0136	0.0029	0.0021	0.0017
	No. 18	0.0103	0.0046	0.0031	0.0019
	No. 19	0.0129	0.0023	0.0029	0.0019
	No. 20	0.0126	0.0021	0.0024	0.0013
General average........		0.0125	0.0037	0.0028	0.0020
		Average total amount of wear........0.0210			
Standard deviation.....		0.0013	0.0009	0.0006	0.0007
Final average[a].........		0.0130	0.0038	0.0028	0.0019
		Final average total amount of wear...0.0215			
Maximum...........		0.0141	0.0048	0.0049	0.0035
Minimum...........		0.0096	0.0021	0.0019	0.0006
Number of readings omitted by means of the first standard deviation to determine the final average		5	5	4	5

[a] Final average determined by elimination of high and low readings with first standard deviation.

Conclusions

The results of tests as outlined on Tables I, II, and III for the resistance to wear of teak wood, linoleum and light-weight walkway material indicate that although the rate of wear varies in the same specimen as well as between specimens of any of the materials tested, the percentage of total observations lying within given ranges compares favorably with the theoretical estimated percentages specified by the A.S.T.M.[3] for data obtained under controlled conditions (see Table IV). It is, therefore, considered that the wear test machine offers a satisfactory method for evaluating the wear of walkway materials.

Although the wear test machine described in this paper is not proposed as a universal solution for the problem of wear resistance, it is believed that its use, as discussed above, can be successfully extended to almost all walkway materials and to other materials which are subjected to similar conditions of wear. In this connection, the wear test machine in its present form offers a high degree of versatility in so far as the factors such as speed, amount of lift of specimen, amount of abrasive, size and kind of abrasive, material on the face of the abrasion disk, ratio of specimen shaft speed to abrasion disk speed, size of the specimen, configuration of the specimen and load on the specimen can be varied independently to give the combination of conditions most closely approximating actual service.

[3] A.S.T.M. Manual on Presentation of Data, August, 1940.

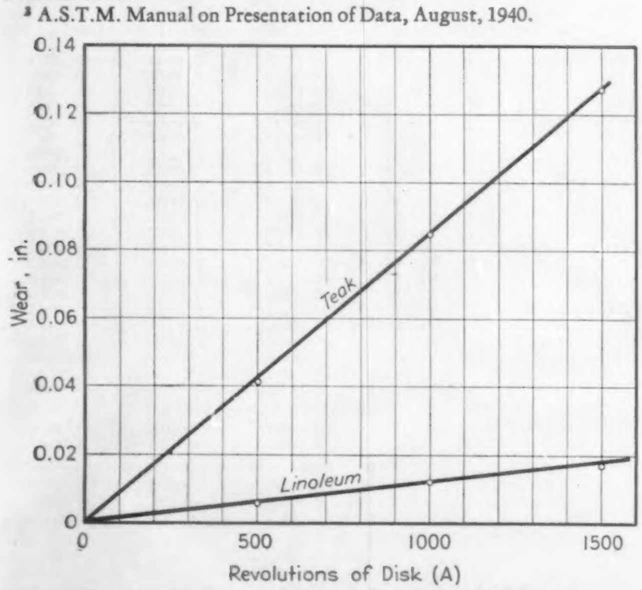


Fig. 6.—Results of Tests on Wear Test Machine.

TABLE IV.—COMPARISON OF OBSERVED PERCENTAGES AND THEORETICAL ESTIMATED PERCENTAGES OF THE TOTAL OBSERVATIONS LYING WITHIN GIVEN RANGES.

Range, Average, X, plus or minus[a]	Estimated Percentage[b]	Observed Percentages			
		Teak			
		0 to 500 revolutions	500 to 1000 revolutions	1000 to 1500 revolutions	
1 σ.......	68.3	70.0	65.0	75.0	
2 σ.......	95.5	90.0	100.0	90.0	
3 σ.......	99.7	100.0	100.0	100.0	
		Linoleum			
		0 to 500 revolutions	500 to 1000 revolutions	1000 to 1500 revolutions	
1 σ.......	68.3	75.0	70.0	75.0	
2 σ.......	95.5	95.0	95.0	95.0	
3 σ.......	99.7	100.0	100.0	100.0	
		Light-Weight Walkway Material			
		0 to 25 revolutions	25 to 50 revolutions	50 to 75 revolutions	75 to 100 revolutions
1 σ.......	68.3	75.0	75.0	80.0	75.0
2 σ.......	95.5	95.0	95.0	95.0	85.0
3 σ.......	99.7	100.0	100.0	95.0	100.0

[a] σ = standard deviation.
[b] Theoretical estimated percentages of total observations, as shown on Fig. 14 of A.S.T.M. Manual on Presentation of Data, August, 1940.

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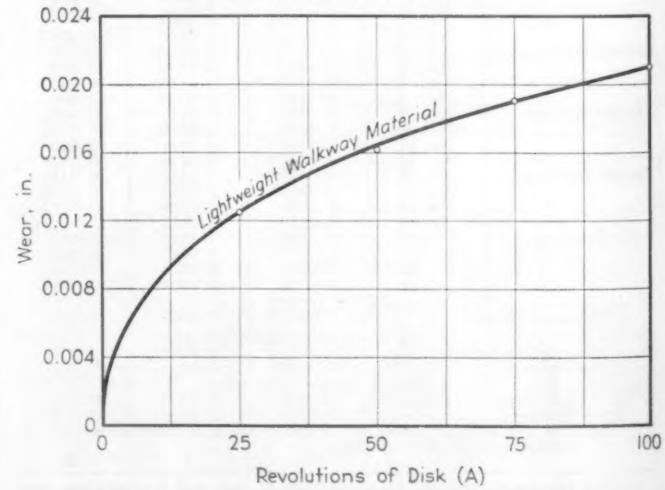

Fig. 7.—Results of Tests on Wear Test Machine.

A Suggested New Parameter for Fatigue Strength Analysis

Victor Seliger[1]

Synopsis

A new parameter, $K_{f_0} \cos R$, is suggested for use in the presentation of fatigue strength properties and in the analytical development of fatigue strength theory. Its advantages and possible limitations are discussed in the light of presently available data. The need for more developments such as this is emphasized.

Nomenclature

Ft_f = Fatigue strength of basic material, in terms of the maximum stress attained during a cycle. A numerical value of Ft_f must be accompanied by a numerical value of N (see below) and by a numerical value of R (see below).

ft_f = Fatigue strength of part in terms of the maximum (nominal) stress attained during a cycle without regard to stress concentration. As for Ft_f, numerical values must be accompanied by numerical values of N and R.

R = Range ratio (ratio of minimum stress to maximum stress, produced during a cycle).

N = Number of cycles of loading required to produce failure.

S-N curve = Standard designation of curve showing maximum applied stress as a function of the number of cycles required to produce failure, for a constant value of R. Usually plotted on semilogarithmic coordinates.

K_f = $\left(\frac{F_{tf}}{f_{tf_0}}\right)_{\substack{R\ \text{constant}\\ N\ \text{constant}}}$ = Effective stress concentration factor in fatigue.

$K_{f_0} \cos R$ = Proposed parameter. R is in radians.

d = Diameter of hole.

D = Width of strip.

g = Subscript indicating that stress calculations are based on the gross area of the specimen or part.

It is becoming more and more essential that the airplane designer and stress analyst be able to predict, with reasonable certainty, the service behavior of the airplane structure. To make such a prediction the designer must consider not only static strength (strength to resist a single slowly applied load) but also dynamic strength (strength to resist suddenly or repeatedly applied loads).

No attempt will be made to defend the foregoing statements; the design trends are well established and, when analyzed without prejudice, lead to unmistakable conclusions.[2] Granted the validity of these conclusions, then, just as the designer and stress analyst is already possessed of many theoretical and empirical relations useful in the prognostication of static strength, so he must endeavor to formulate similar relations in regard to dynamic strength. This paper deals with one such relation in regard to the fatigue strength of a structure possessing stress raisers.

During flight the components of an aircraft structure are loaded in so many ways and to such a variety of magnitudes, that the problem of design for fatigue strength is most complicated; and the strength for a completely reversed stress and an infinite life is no longer the only unknown factor to be evaluated. It is now necessary to know the fatigue strength of a great many more types of constructions than heretofore. Besides, all numbers and summations of repeated loads for all combinations of mean and varying stress (that is, for all range ratios) must be studied and evaluated. Obviously, this vast quantity of information necessary to formulate the theory upon which aircraft structures may be designed for a definite life expectancy makes it necessary to develop all possible simplifying procedures: the number of basic parameters must be condensed to a minimum. Even the results of the direct tests now used for checking the fatigue strength of current designs involve a considerable number of interdependent and sometimes confusing variables.

In the development of simplifying procedures, the most logical first step is to reduce the amount of test data required, and to present the results of an analysis of such test data in simple, easy-to-use form. At the Lockheed Aircraft Corp., the importance of this step was recognized nearly four years ago and hence all test data have, whenever possible, been collected in the form of S-N curves at constant R. By this means it has been possible to utilize judicious cross-plotting and interpolation as a means of effectively decreasing the number of test points required for a complete definition of the fatigue strength of a given material or construction. Also, such a complete definition is conveniently presented on a single page as a family of S-N curves of constant R. (Refer to Figs. 6 and 7 for examples.)

Another simplification and clarification is the use of the effective stress concentration factor in fatigue, K_f. This factor isolates quantitatively the effect of various discontinuities and other stress raisers upon the fatigue strength of structures and structural components. The parameter is fully discussed in an earlier paper by the author[3] and a summary of its definition and use is presented in the Appendix to the present paper. It is shown in the earlier paper[3] that K_f is a function of maximum stress. Subsesequent analyses have shown that it also depends upon the range ratio R. Thus, to describe fully the fatigue strength of a structure, a family of effective stress concentration factor curves must be presented. Figure 1 shows a typical example of such a presentation, in this case the result of an investigation of the fatigue properties of a single-row riveted lap joint. At this time it should be noted that K_f may be defined on either net area or gross area. In this paper K_f is defined on a gross area basis, and the subscript g (gross area) is used to eliminate any possibility of misunderstanding.

A desirable simplification would be the discovery of the fundamental relation between K_f and R. If such a relation could be found, then the fatigue properties of a construc-

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A. S. T. M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

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[2] R. B. Bland and P. E. Sandorff, "The Control of Life Expectancy in Airplane Structures," *Aeronautical Engineering Review*, Vol. 2, No. 8, August, 1943, and references listed therein.

[3] Victor Seliger, "Effect of Rivet Pitch on the Fatigue Strength of 0.025–0.025 Alclad 24S-T Riveted Joints," *N.A.C.A. Technical Note*, No. 900, July, 1943.

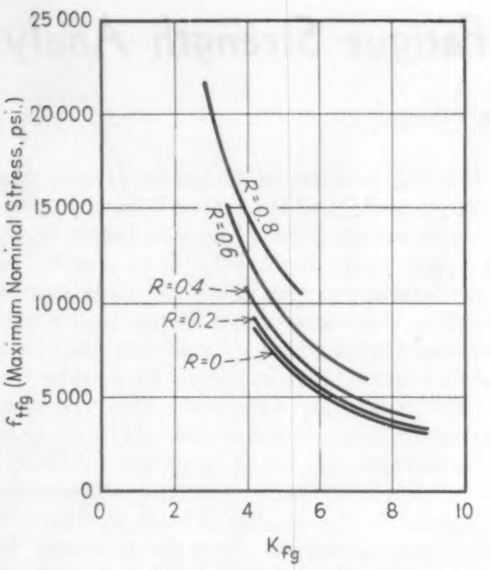


Fig. 1.—Effective Stress Concentration Factor in Fatigue Curves for a Single Row Riveted Lap Joint Constructed from 0.051 Alclad 24S-T Aluminum Alloy. 6 AN426DD-6 Rivets at 1 in. Spacing.

tion could be determined by determining a single *S-N* curve, thus saving considerable time and money. The problem is currently not amenable to mathematical analysis because of the large number of unknown factors involved. However, an empirical relation (or parameter) has been found that appears to fit the observed data with good accuracy; this parameter will be the subject of the following discussion.

The Proposed Parameter

The curves of Fig. 1, involving three parameters, K_{fg}, R, and the maximum nominal stress, f_{tfg} may be replotted on polar coordinates as the constant stress curves of Fig. 2, with R plotted in radians. Study of this plot reveals a property common to all structural elements thus far fully investigated at Lockheed: the curves closely approach straight lines perpendicular to the $R = 0$ axis. Such a relationship allows the projection of any value of K_{fg} on the $R = 0$ axis by multiplying that value by the cosine of its corresponding range ratio in radians; in other words, the family of curves shown in Fig. 2 becomes a series of points when the parameter K_{fg} cos R is substituted for K_{fg}. Obviously, under such conditions, a plot of all possible values of f_{tfg} against K_{fg} cos R will reduce to a single

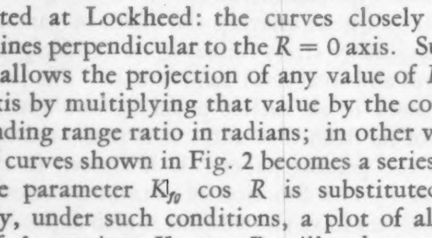


Fig. 2.—Replot of Fig. 1 on Polar Coordinates in Terms of Constant Maximum Nominal Stress Curves.

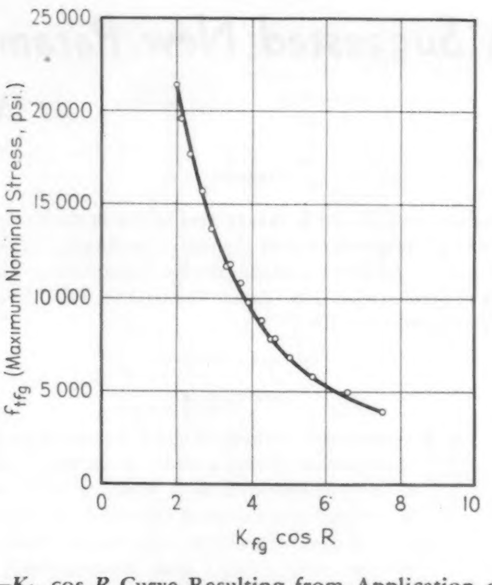


Fig. 3.—K_{fg} cos R Curve Resulting from Application of This Parameter to Curves of Fig. 1.

curve; this has been done in Fig. 3, which is a replot of Fig. 1 using the new parameter. The transformation was performed by picking, at random, several points on each of the curves of Fig. 1, applying the proper cos R multiplicand, as in Table I, and plotting the resulting points as shown in Fig. 3.

If the proposed parameter holds for all cases—that is, if for all values of R lying between 0 and 1.0, the K_f families can be reduced to a single curve by applying the cos R factor—then a big forward step has been taken in the field of dynamic stress analysis, as the presentation of fatigue properties can be much simplified and the number of tests required to determine K_f can be reduced to a minimum. Further, if theoretical substantiation for the use of the proposed parameter can be developed, such substantiation should considerably advance the development of a rational fatigue strength theory.

Space does not permit a graphic presentation of the application of this parameter to all other structural elements presently under investigation. Two typical results, however, are shown in Figs. 4 and 5.

It must be emphasized that all present discussion is limited to fatigue in the tensile range, that is, to range ratios of between 0 and +1.0. Nothing is yet known concerning

TABLE I.

Maximum Nominal Stress, psi.	R	K_{fg}	K_{fg} cos R
3 920	0	7.40	7.40
3 920	0.2	7.65	7.50
4 900	0.4	7.10	6.53
5 900	0	5.50	5.50
5 900	0.2	5.68	5.56
5 900	0.4	6.10	5.60
6 850	0	5.00	5.00
7 850	0	4.50	4.50
7 850	0.2	4.70	4.60
7 850	0.4	5.00	4.59
8 800	0	4.10	4.10
8 800	0.4	4.60	4.25
9 800	0.2	3.95	3.87
9 800	0.4	4.25	3.90
9 800	0.6	4.80	3.83
10 400	0.6	4.47	3.70
10 900	0.4	3.70	3.39
10 900	0.6	4.16	3.32
13 750	0.8	4.20	2.92
15 700	0.8	3.75	2.61
17 600	0.8	3.40	2.36
19 600	0.8	3.10	2.16
21 500	0.8	2.90	2.02

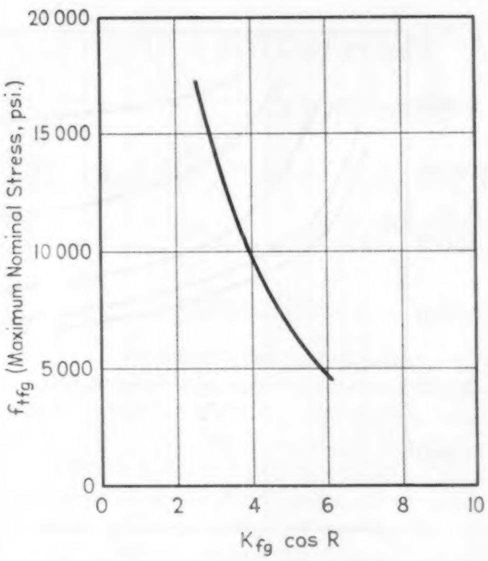


Fig. 4.—K_{fg} cos *R* Curve for a Single Row Riveted Lap Joint Constructed from 0.064 Alclad 24S-T Aluminum Alloy. 6 AN430DD-6 Rivets at 1 in. Spacing.

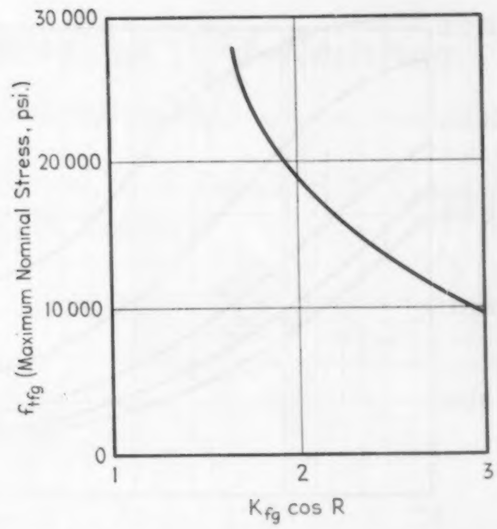


Fig. 5.—K_{fg} cos *R* Curve from Complete Fatigue Strength Data on 0.032 Alclad 24S-T Aluminum Alloy Strip with a Reamed, Polished Hole. d/D—$^1/_6$.

the behavior of K_f where the minimum stress of the cycle enters the compressive range. In addition, the parameter has only been applied to the analysis of structures fabricated from Alclad 24S-T aluminum alloy, as data for other materials are currently lacking.

Statistical Substantiation and Cautions:

Since the suggested parameter has been arrived at empirically and is thus far without theoretical substantiation, the probability of its universality can only be conjectured. Yet weighty evidence of its validity and of at least a limited generality can be brought to bear. This evidence is presented in Table II and includes an analysis of certain of the available data. The following procedure was used in compiling this table: Four points were selected at random from each curve of the original K_{fg} family, and, with the proper multiplicand applied, used to plot a K_{fg} cos *R* curve drawn through the mean of the resulting scatter of points. Percentage K_{fg} deviation from this curve of each point was then determined and averaged. The fourth column of Table II gives these averages. The percentage corresponding to the magnitude of greatest deviation is given in the fifth column. It will be noted that in this series the percentage mean deviation varies between 0.96 per cent and 4.12 per cent with an average of 2.18 per cent, while the maximum observed deviation of any point in the entire series is 12.8 per cent. In view of the normal scatter of test results and the variation in material properties to be expected from sheet to sheet, it is considered that the congruence between the individual curves of the K_{fg} families obtained by use of the cos *R* parameter is exceptionally good. Nonetheless, much additional experimental evidence and, if possible, a mathematical proof should be made available before free use of this parameter can be recommended. This caution should be particularly observed in using this parameter for predicting K_f curves at several range ratios after the experimental determination of one K_f curve. Where complete K_f curves are already available, however, its employment as a simplifying step for use in design is safe. For in such an instance any deviations from true values resulting from its use are known.

TABLE II.

	Type of Specimen Investigated[a]	Number Points Used	Mean Deviation, per cent	Maximum Observed Deviation, per cent
No. 1	0.040 Gage AN430DD-5 Rivets	20	3.75	12.80
No. 2	0.040 Gage AN426AD-5 Rivets	20	2.26	3.90
No. 3	0.040 Gage LS1126-5 "Cherry" Rivets	20	4.12	7.50
No. 4	0.040 Gage LS1127-5 Rivets	20	2.05	8.25
No. 5	0.051 Gage AN426DD-6 Rivets	20	1.20	2.44
No. 6	0.051 Gage LS1126-6 "Cherry" Rivets	20	0.96	5.15
No. 7	0.064 Gage AN430DD-6 Rivets	20	1.65	3.90
No. 8	0.081 Gage AN426DD-6 Rivets	20	2.76	7.50
No. 9	0.064 Gage AN430DD-8 Rivets	20	2.45	6.85
No. 10	0.081 Gage AN426DD-6 Rivets	20	1.72	6.31
No. 11	0.032 Alclad 24S-T Strip with Reamed Hole $d/D = {}^1/_6$	12	1.10	2.20

[a] Specimens 1 to 10, inclusive, are single row riveted lap joints, made from Alclad 24S-T Aluminum Alloy. Rivet spacing 1 in., total of 6 rivets.

Conclusion

It is hoped that the additional data necessary to justify a wide application of the new parameter both in research and design will shortly be available. Until such time it is hoped that this paper will serve to stimulate discussion and criticism of the use of the proposed parameter, and to advance somewhat the formulation of a rational fatigue strength theory. The development of such a theory is very much dependent upon the development, definition, and standardization of a proper and well-defined set of parameters.

Acknowledgment:

The author wishes to express his appreciation to Messrs. R. B. Bland, D. W. Drake, and H. W. Foster for valuable aid in the planning and in the editing of this paper.

APPENDIX

In order that those not familiar with the concept of the effective stress concentration factor in fatigue may become acquainted with its definition and use, the following short discussion is presented:

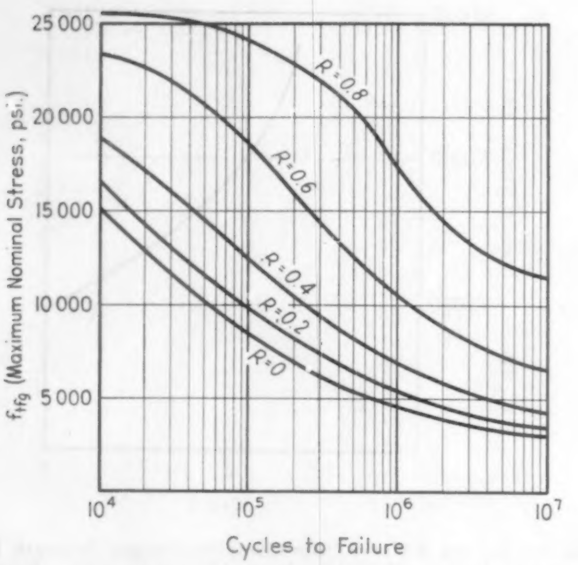


Fig. 6.—Complete Tensile *S-N* Curves for Riveted Joint Referred to in Fig. 1.

A comprehensive series of fatigue tests on a structural component results in a family of *R* curves. In order to obtain from these data values of K_{fo} we must also have *S-N* curves available for the unnotched material which proved critical in fatigue. K_{fo} is then the ratio of the maximum stress the material will withstand for a given range ratio and a given number of cycles to failure, to the maximum gross area nominal stress the structural component will withstand for the same *R* and cycles to failure. That is

$$K_{fo} = \left(\frac{F_{tf}}{f_{tfo}}\right)_{\substack{R \text{ constant} \\ N \text{ constant}}}$$

As first *N* and then *R* are varied, a complete family of K_{fo} curves is defined.

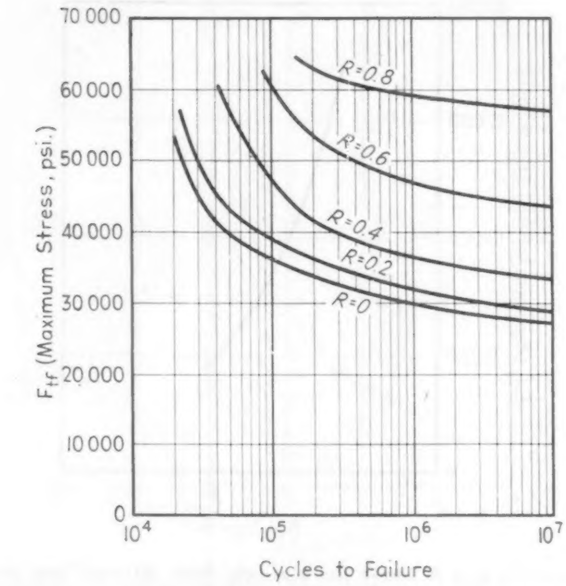


Fig. 7.—Complete Tensile *S-N* Curves for Alclad 24S-T Aluminum Alloy.

More specifically, let us examine the curves of Fig. 6. This is a complete family of *S-N* curves for a single row riveted joint made from Alclad 24*S-T* aluminum alloy, which, in this case, is the material critical in fatigue. For the range ratios under investigation, complete tension fatigue data for Alclad 24*S-T* aluminum alloy were obtained at Lockheed and are shown in Fig. 7. To establish a specific point for our K_{fo} curves, say at $R = 0.2$ and $N = 10^6$ cycles, we see from Fig. 7 that $F_{tf} = 39{,}000$ psi. and, from Fig. 6, $f_{tfo} = 9800$ psi., or $K_{fo} = 39{,}000/9800 = 3.98$. At the same range ratio but at $N = 10^7$ cycles $K_{fo} = 29{,}000/3530 = 8.21$, and so on. The final result of this analysis is the family of curves of Fig. 1, which describes completely the fatigue characteristics of this particular structural component.

Volumes on Precision Measurement in the Metal Working Industry

Issued in two extensive volumes this book, covering precision measurement, was prepared by the Department of Education of International Business Machines Corp. and published by the Syracuse University Press. It should be extremely interesting and valuable to all who are concerned with the wide range of topics covered under this general heading of Precision Measurement. The book is particularly timely because of the relation of this subject to war matériel.

Volume I (270 pages) gives some general introductory information and then covers in successive chapters Nonprecision Line-Graduated Measuring Instruments, Micrometer and Vernier Type Instruments, Precision Gage Blocks, Fixed Gages, Thread Gages and Dial Gages, and Test Indicators. Each chapter gives detailed information and data essential to an understanding of the use and care of the instruments involved.

Volume II relates to Surface Plates and Accessories, Angles, Comparison Measurement, Optical Instruments, Measuring Machines, Surface Roughness and Hardness Testing. In the preparation of the book, the IBM Educational Department has drawn on the extensive knowledge of the Engineering and Manufacturing Departments and has consulted leading manufacturers of gages, testing and precision instruments. The material incorporated has been used in classrooms in various arsenals, Army and Navy schools, industrial classes, and the constructive criticisms resulting have been given cognizance in the preparation of the formal printed volumes.

One feature of both volumes which merits comment is the very profuse use of illustrations and drawings. A well-selected photograph or series of illustrations frequently will convey more than a great amount of printed matter. That is particularly true in the case of problems discussed in this book, and the great number of figures and drawings make for a quick grasp of the subjects detailed. Printed on coated stock, the illustrations are clear throughout. Copies of the book, 8 by $10^3/_4$ in., in blue cloth binding, can be obtained from the Syracuse University Press, Syracuse, New York, a $7.50, per set.

Handbook on Malleable Iron

Just issued by the Malleable Founders' Society is a Handbook on American Malleable Iron which doubtless will be of interest to many members and other Bulletin readers. In preparation for many months, the volume is a compact unit giving complete data on manufacturing procedure, recent standards and practices and other important information of service to the producer, but primarily for users and designers. Separate chapters cover physical, mechanical and engineering properties of standard irons, then the pearlitic and cupola irons are covered, followed by information on pattern and casting design and machining practice. There is considerable information dealing with the manufacture and metallurgy of this material and other important parts of the Handbook dealing with recommendations to users and applications of American malleable iron. There is considerable tabular material and many illustrations. Copies of the 316-page book can be obtained from the Malleable Founders' Society, Union Commerce Building, Cleveland, Ohio, at $4.00 per copy.

High Temperature Oven Aging of Oil-Resisting Synthetic Rubber Compounds[1]

By G. D. McCarthy,[2] A. E. Juve,[3] H. Boxser,[4] M. Sanger,[5] S. R. Doner,[6] E. N. Cunningham,[7] J. F. McWhorter,[8] and R. H. Crossley[9]

Introduction

Synthetic rubber vulcanizates of all types commercially available today when exposed to elevated temperatures in an air oven become stiffer; that is, the modulus increases and the elongation is reduced. This change is thought to be due principally to a cyclization of the rubber which apparently requires the presence of oxygen. In addition, some stiffening may be due to the loss of volatile plasticizers during the heating. Early in the program of development of stocks to withstand 300 F. oven tests, it was discovered that the results obtained were quite erratic and depended to a considerable extent on the volume of air (or the concentration of oxygen) to which the samples were subjected. It was the objective of the work undertaken by this subsection to study the effects of variables in the oven testing procedure and to devise if possible a reproducible laboratory technique for conducting air oven tests at 300 F. or other temperatures higher than those normally used in rubber testing. The work done was confined to vulcanizates of the SB type.[10]

Procedure

The work done consisted of three parts, the first being a study of widely different methods of exposures for the purpose of determining the factors influencing deterioration, the second a study of the duplicability of a refinement of one of the methods used in the first part, and the third a study of time and temperature relations using the latter method.

Three compounds designated A, B, and C, were chosen for testing and the recipes are given in Table I. Compound A is a heat-resisting type containing a volatile plasticizer, compound B is similar except that the plasticizer was omitted, and compound C is a conventional stock not designed for heat resistance. Service experience has shown that stocks similar to A and B perform more satisfactorily in high-temperature service than stocks similar to C.

Samples of the three compounds were prepared by The Ohio Rubber Co. In order that no variables due to the use of different dies or cutting methods would be introduced, the dumbbells were cut by Ohio Rubber and distributed by them to the cooperating laboratories. This procedure was followed in all three studies.

TABLE I.—THREE COMPOUNDS CHOSEN FOR TESTING.

	Compound A	Compound B	Compound C
Hycar OR-15	50	50	50
Perbunan	50	50	50
Stearic acid	0.5	0.5	0.5
AgeRite resin D	5	5	5
Zinc oxide No. 72	5	5	5
SRF black (Gastex)	70	70	70
Sulfur	...	...	1.5
Tuads	3	3	...
Captax	1.5	1.5	1.5
Plasticizer SC	15	...	15
	200	185	198.5

Cured 25 min. at 307 F.

Part I.—Study of Methods of Exposure

Each laboratory of the four in this study ran the following tests:

1. Original properties—tensile strength, ultimate elongation, modulus, and durometer hardness.
2. Properties after 70 hr. at 300 F. in mercury or a low melting alloy.
3. Properties after 70 hr. at 300 F. in circulating nitrogen.
4. Properties after 70 hr. at 300 F. in a bottle of 250 ml. capacity.
5. Properties after 70 hr. at 300 F. in a bottle of 375 ml. capacity.
6. Properties after 70 hr. at 300 F. in a bottle of 500 ml. capacity.
7. Properties after 70 hr. at 300 F. in circulating air oven with intake port closed.
8. Properties after 70 hr. at 300 F. with intake port open.

In addition, the heat loss during each test was measured and a 180-deg. bend test was made.

Part II.—Study of Duplicability of Refinement on Bottle Test

The bottle test used in Part I was modified in the following respects:

1. Containers for samples were test tubes 38 by 300 mm.
2. Test tubes were heated by immersion in an oil bath maintained at 300 F.
3. Test tubes were stoppered with an unvented cork.
4. Samples were suspended as near the bottom of the test tube as possible.

The following tests were run by six cooperating laboratories:

1. Original tensile strength, ultimate elongation, and durometer hardness.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A. S. T. M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] The authors of this paper constitute a subsection of Section IV on Classification and Specifications of Rubber Compounds of Technical Committee A of A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials. This paper serves as a progress report of that group.

[2] Chrysler Corp., Detroit, Mich.
[3] The B. F. Goodrich Co., Akron, Ohio.
[4] Acadia Synthetic Division, Western Felt Works, Chicago, Ill.
[5] The General Tire and Rubber Co., Akron, Ohio.
[6] Manhattan Rubber Division of Raybestos-Manhattan, Inc., Passaic, N. J.
[7] Stanco Distributors, Inc., New York, N. Y.
[8] Ohio Rubber Co., Willoughby, Ohio.
[9] Xylos Rubber Co., Akron, Ohio.

[10] See Table IV of A.S.T.M. Tentative Specifications for Rubber and Synthetic Rubber Compounds for Automotive and Aeronautical Applications, 1944 Book of A. S. T. M. Standards, Part III, p. 1809.

2. Same properties and a 180-deg. bend test after 70 hr. at 300 F.
   (*a*) Three successive times using one specimen per test tube.
   (*b*) Three successive times using three specimens per test tube.

Part III.—Study of Time and Temperature Relations

Using the same technique as above and with three specimens per test tube a series of tests was run on compounds A and B by seven cooperating laboratories as follows:

1, 2, 4, 8, 16, 32, 48, and 70 hr. at 300 F.
8, 16, 32, 64, and 128 hr. at 250 F.

Parts I, II, and III were run at different times and a different lot of test specimens was supplied for each part. Although the compositions of the stocks were identical in all three parts, slight differences in materials and processing may have occurred which caused slight variations in the original properties.

Results

The results obtained in the three parts of this study are given in Tables II to V and Figs. 1 to 5.

The percentage deviation as used in this report is the average deviation expressed as a percentage of the average value for the property being considered.

Discussion

From the data in Table II and in Figs. 1 and 2 it will be seen that the oven tests were too severe, as they nearly completely deteriorated all compounds without consistently distinguishing between the heat-resisting and non-heat-resisting compounds. Moreover, the deviation between laboratories, particularly in elongation, was found to be extremely high.

On the other hand, the test in molten metal was not severe enough to differentiate between the compounds. The test in nitrogen, although more severe, was still not severe enough to differentiate between the compounds.

The bottle tests, although nearly as severe as the oven tests, were nevertheless more duplicable and differentiated in every case between the heat-resisting and non-heat-resisting compounds, particularly in elongation retention and the 180-deg. bend test. See Table V.

Figure 3 shows a breakdown of the change in durometer hardness of compound A attributable to various changes in the conditions of exposure. These data, as well as the tensile and elongation data, indicate that the changes in elongation and hardness are approximately proportional to the air (or oxygen) available during the test. In both the molten metal and circulating nitrogen tests, all oxygen could not be excluded since it is virtually impossible to remove traces of oxygen dissolved or occluded in

TABLE II.—AVERAGES OF TESTS BY ALL LABORATORIES—PART I.

	Compound A			Compound B			Compound C		
	Properties	Change	Deviation, per cent	Properties	Change	Deviation, per cent	Properties	Change	Deviation, percent
Original									
Tensile strength	1700	....	2.6	2140	....	3.6	2324	....	2.6
Elongation	840	....	2.8	630	....	6.4	552	....	9.1
Durometer hardness	52	....	....	66	....	....	60	....	....
70 Hr. at 300 F. in Molten Metal									
Tensile strength	2140	+25.5%	6.4	2680	+26.0%	2.4	2630	+13%	2.7
Elongation	540	−36.0%	15.3	470	−27.0%	13.3	319	−42%	16.0
Durometer hardness	56	+ 4	....	69	+ 3	....	65	+ 6	....
Weight change, per cent	+0.1	....	....	+0.3	....	....	+0.37	....	....
180-deg. bend	OK	....	....	OK	....	....	OK	....	....
70 Hr. at 300 F. in Circulating Nitrogen									
Tensile strength	1270	−26.0%	10.1	1795	−16.0%	15.3	1459	−37.0%	18.5
Elongation	245	−71.0%	5.6	205	−67.0%	12.2	180	−67%	23.3
Durometer hardness	64	+11.5	....	72	+ 6	....	69	+ 9	....
Weight change, per cent	−4.7	....	....	−1.88	....	....	−3.5	....	....
180-deg. bend	OK	....	....	OK	....	....	OK	....	....
70 Hr. at 300 F. in 250-Ml. Bottles									
Tensile strength	1080	−37%	16.0	1589	−25%	12.2	771	−67%	11.2
Elongation	100	−88%	30	109	−85%	31.2	31	−94%	29.8
Durometer hardness	72	+20	....	79	+13	....	80	+20	....
Weight change, per cent	−0.8	....	....	−0.45	....	....	−0.6	....	....
180-deg. bend	OK	....	....	OK	....	....	NG	....	....
70 Hr. at 300 F. in 375-Ml. Bottles									
Tensile strength	1304	−31%	15.5	1365	−36.6%	7.5	1022	−56%	.2
Elongation	140	−83%	51.8	90	−86%	18.4	57	−90%	19.3
Durometer hardness	70	+18	....	81	+18	....	78	+17	....
Weight change, per cent	−0.7	....	....	−0.97	....	....	−0.13	....	....
180-deg. bend	OK	....	....	OK	....	....	NG	....	....
70 Hr. at 300 F. in 500-Ml. Bottles									
Tensile strength	1120	−33%	28.6	1221	−42%	15.2	970	−58%	10.3
Elongation	120	−86%	27.7	86	−87.5%	18.7	45	−92%	7.3
Durometer hardness	71	+18	....	83	+18.7	....	79	+20	....
Weight change, per cent	−0.9	....	....	−0.35	....	....	+1.1	....	....
180-deg. bend	OK	....	....	OK	....	....	NG	....	....
70 Hr. at 300 F. in Circulating Air Oven—Limited Air									
Tensile strength	800	−53%	15.8	757	−65%	22.3	603	−74%	11.4
Elongation	40	−95%	65.0	32	−94%	90.8	15	−97%	44.7
Durometer hardness	84	+32	....	86	+19.7	....	87	+27	....
Weight change, per cent	−9.9	....	....	−4.2	....	....	−9.7	....	....
180-deg. bend	NG	....	....	NG	....	....	NG	....	....
70 Hr. at 300 F. in Circulating Air Oven—Unlimited Air									
Tensile strength	560	−67%	18.5	668	−68.7%	18.1	587	−75%	25.8
Elongation	30	−96%	50.0	35	−94%	94.3	18	−97%	61.0
Durometer hardness	87	+35	....	88	+23	....	91	+31	....
Weight change, per cent	−10.6	....	....	−4.1	....	....	−9.3	....	....
180-deg. bend	NG	....	....	NG	....	....	NG	....	....

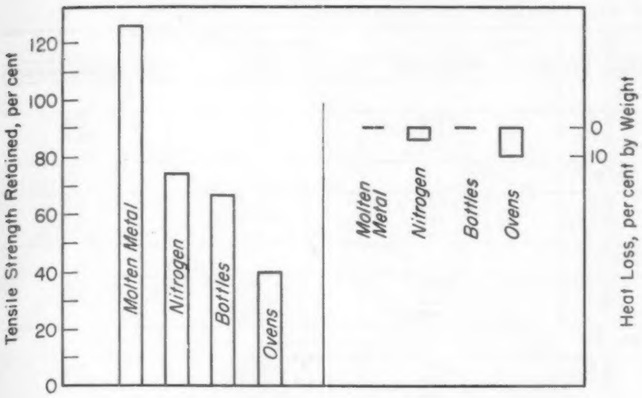


Fig. 1.—Heat Aging Tests, 70 hr. at 300 F.—Compound A.

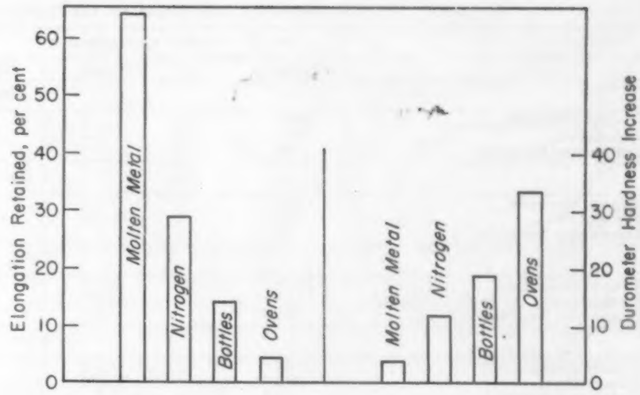


Fig. 2.—Heat Aging Tests, 70 hr. at 300 F.—Compound A.

the specimens. Also, commercial nitrogen contains traces of oxygen. There was little difference between the results obtained in the static air tests in the three sizes of bottles, which indicates that variation in the oxygen supply over this range has little effect. The difference between the static air tests and the circulating air oven tests is probably due both to the greater volume of available oxygen and to the loss in plasticizer. Appreciable loss of plasticizer occurred only in those tests in which a circulating medium was used.

It is probable that all the changes taking place, exclusive of those due to plasticizer loss, are the result of heating in the presence of oxygen.

The factors which must be most carefully controlled are the availability of oxygen and the temperature. Since it is extremely difficult to control the temperature in different parts of a circulating air oven within narrow limits and to control the volume of air per unit area of sample exposed, it seemed that the static air test using test tubes immersed in an oil bath would have the best possibility of fulfilling both of these requirements.

The data on these tests given in Table III indicate excellent reproducibility and a measurable distinction between the heat-resisting and non-heat-resisting compounds. It was felt that this distinction was not as sharp as it should be, due to the severity of the deterioration. The differences between the use of one strip per test tube and three strips were slight and not sufficient to warrant this restriction in testing capacity. A comparison of the deviation between laboratories for the elongation deterioration after various conditions of exposure is shown in Fig. 4.

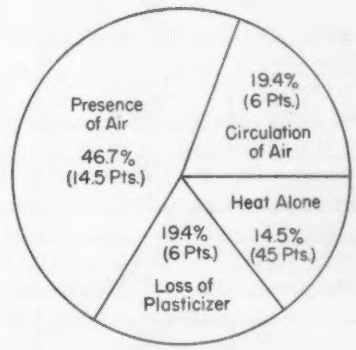


Fig. 3.—Effect of Various Factors on Hardening of Compounds A and C.

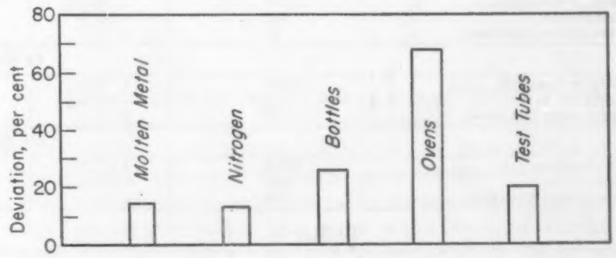


Fig. 4.—Deviation in Elongation Tests. Averages for Compounds A, B, and C Tested by All Laboratories Under Various Conditions of Exposure.

TABLE III.—AVERAGES OF TESTS BY ALL LABORATORIES—PART II.

	Compound A			Compound B			Compound C		
	Property	Change	Deviation, per cent	Property	Change	Deviation, per cent	Property	Change	Deviation, per cent
ORIGINAL									
Tensile strength	1850	....	3.4	2138	....	2.8	2219	....	3.3
Elongation	825	....	3.8	637	....	3.8	534	....	3.2
Durometer hardness	53	....	5.7	66	....	4.7	58	....	5.2
70 HR. AT 300 F. TEST TUBE METHOD—ONE STRIP PER TEST TUBE									
Tensile strength	1302	−29%	16.0	1553	−26.0%	7.7	842	−62%	7.7
Elongation	102	−88%	9.2	95	−85%	11.0	41	−92%	29.0
Durometer hardness	73	+20	....	79	+12	....	79	+20	....
180-deg. bend	OK	....	....	OK	....	....	NG	....	....
70 HR. AT 300 F.—TEST TUBE METHOD—THREE STRIPS PER TEST TUBE									
Tensile strength	1107	−40%	10.4	1431	−32%	6.5	789	−64%	9.0
Elongation	97	−88%	11.0	107	−82%	19.7	47	−92%	43.0
Durometer hardness	72	+19	....	78	+11	....	77	+18	....
180-deg. bend	OK	....	....	OK	....	....	NG	....	....

TABLE IV.—AVERAGES OF TESTS BY ALL LABORATORIES—PART III.

	Compound A			Compound B		
	Property	Change	Deviation, per cent	Property	Change	Deviation, per cent
ORIGINAL						
Tensile strength	2039	....	4.4	2576	....	1.5
Elongation	618	....	5.0	522	....	4.8
Durometer hardness	54	....	....	64.3	....	....
1 HR. AT 300 F.						
Tensile strength	2116	+ 3.7%	6.9	2823	+ 9.5%	3.0
Elongation	507	−18.0%	6.3	449	−13.87%	4.0
Durometer hardness	55	+ 1	....	66.1	+ 1.8	....
2 HR. AT 300 F.						
Tensile strength	2118	+ 3.9%	3.0	2788	+ 8.0%	2.6
Elongation	447	−28.0%	4.7	403	−22.7%	6.2
Durometer hardness	56.6	+ 2.6	....	66.5	+ 2.2	....
4 HR. AT 300 F.						
Tensile strength	2229	+ 9.3%	4.4	3001	+17.0%	4.6
Elongation	396	−36.0%	9.1	357	−31.5%	10.9
Durometer hardness	57.8	+ 3.8	....	67.5	+ 3.2	....
8 HR. AT 300 F.						
Tensile strength	2208	+ 8.3%	5.3	2973	+15.4%	7.9
Elongation	382	−38.2%	8.1	340	−34.8%	7.8
Durometer hardness	59	+ 5	....	69	+ 4.7	....
16 HR. AT 300 F.						
Tensile strength	2201	+ 7.9%	8.9	2781	+ 8%	6.6
Elongation	311	−49.7%	7.7	289	−44.6%	8.4
Durometer hardness	59.8	+ 5.8	....	70	+ 5.7	....
32 HR. AT 300 F.						
Tensile strength	1748	−15.5%	3.3	2078	−19.4%	14.4
Elongation	238	−61.5%	5.0	194	−62.8%	8.7
Durometer hardness	63	+ 9	....	71	+ 6.7	....
48 HR. AT 300 F.						
Tensile strength	1510	−26%	15.3	1865	−27.6%	15.4
Elongation	175	−71.7%	7.1	165	−68.4%	12.1
Durometer hardness	64	+10	....	73	+ 8.7	....
70 HR. AT 300 F.						
Tensile strength	1034	−49.2%	11.1	1398	−45.7%	14.7
Elongation	118	−80.9%	11.8	108	−79.3%	9.3
Durometer hardness	69.5	+15.5	....	76	+11.7	....
8 HR. AT 250 F.						
Tensile strength	2226	+ 9.2%	6.2	2840	+10%	4.8
Elongation	459	−25.7%	7.2	426	−18.3%	6.8
Durometer hardness	57	+ 3	....	67.3	+ 3	....
16 HR. AT 250 F.						
Tensile strength	2163	+ 6.1%	6.7	3053	+18.5%	5.8
Elongation	411	−33.5%	9.0	400	−23.3%	11.1
Durometer hardness	58.5	+ 4.5	....	68.5	+ 4.2	....
32 HR. AT 250 F.						
Tensile strength	2166	+ 6.2%	7.9	3012	+17%	4.7
Elongation	352	−43%	8.1	326	−37.5%	9.1
Durometer hardness	61	+ 7	....	69.3	+ 5	....
64 HR. AT 250 F.						
Tensile strength	2361	+15.8%	9.1	3058	+18.8%	5.6
Elongation	330	−46.5%	9.2	293	−43.8%	6.5
Durometer hardness	62	+ 8	....	72	+ 7.7	....
128 HR. AT 250 F.						
Tensile strength	2390	+17.2%	8.0	3111	+21%	6.1
Elongation	283	−56.2%	10.1	263	−49.6%	6.8
Durometer hardness	66	+12	....	73	+ 8.7	....

TABLE V.

	Compound A		Compound C	
	Percentage Elongation Retained	Bend Test	Percentage Elongation Retained	Bend Test
Molten metal	64	OK	58	OK
Nitrogen	29	OK	33	OK
250-ml. bottle	12	OK	6	NG
375-ml. bottle	17	OK	10	NG
500-ml. bottle	14	OK	8	NG
Oven, limited air	5	NG	3	NG
Oven, unlimited air	4	NG	3	NG

The tests run in Part III were for the purpose of determining whether the temperature coefficient of aging is the same as that reported for GR-S, [11,12] and whether a test at lower temperature carried to the same degree of deterioration would be more duplicable than one run at 300 F.

[11] Staunton R. Harrison and Otis D. Cole, "Time-Temperature Relations in Oven Aging of GR-S," *Industrial and Engineering Chemistry*, Vol. 36, p. 702 (1944).

[12] A. E. Juve and B. S. Garvey, Jr., "The Effect of Time and Temperature of Cure on GR-S Tread Stocks," *Industrial and Engineering Chemistry*, Vol. 36, p. 212 (1944).

In Fig. 5 are shown the elongation and durometer hardness change for compound A at 250 F. and at 300 F. The times at 250 F. were adjusted to equivalent times at 300 F. on the assumption that the rate of change of properties on

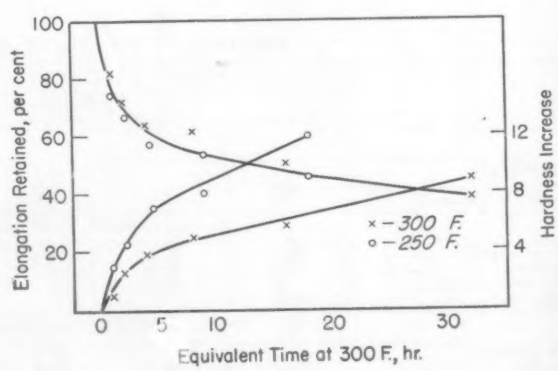


Fig. 5—Effect of Temperature—Compound A.

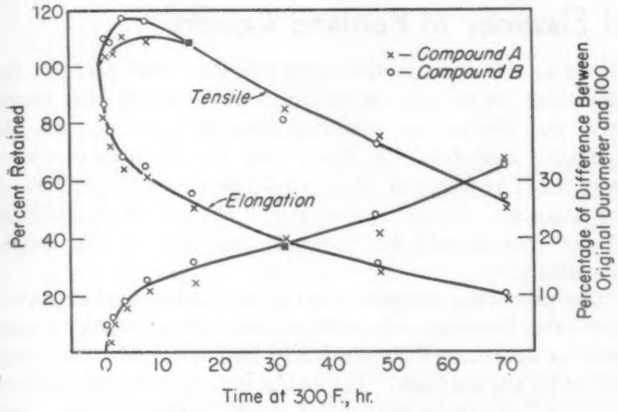


Fig. 6.—Aging of Compounds A and B at 300 F.

aging were doubled for an 18 F. increase in aging temperature. It will be noted that the elongation changes are in accord with this assumption but that the hardness changes are not. For equivalent times on the above basis, the hardness increase is greater at 250 F. than at 300 F. The temperature required for doubling the rate of hardness increase is 42 F.

In Fig. 6 the changes in elongation, tensile strength, and durometer hardness for compounds A and B with time at 300 F. are shown. Except for a slight difference in tensile strength in the first 15 hr. exposure, the curves for compounds A and B are identical. Since the difference between these compounds is only in their plasticizer content, it is apparent that in terms of percentage of properties retained after aging plasticizer makes no difference. It is also evident that the rate of deterioration at 300 F. is quite rapid, and the degree of deterioration after 70 hr. at 300 F. very great.

A comparison of the deviations between laboratories in tensile and elongation retention after exposure for several approximately equivalent periods at 300 and 250 F. is shown in Table VI. Excellent duplicability was obtained at both temperatures. It is probable that a similar test using the conventional circulating air ovens would have shown an appreciable difference in reproducibility in favor of the lower temperature.

TABLE VI.—REPRODUCIBILITY OF TESTS—300 F. *VERSUS* 250 F.

Time at 250 F., hr.	Deviation Between Laboratories, per cent: Tensile	Deviation Between Laboratories, per cent: Elongation	Time at 300 F., hr.	Deviation Between Laboratories, per cent: Tensile	Deviation Between Laboratories, per cent: Elongation
8....	6.2	7.2	1	6.9	6.3
16....	6.7	9.0	2	3.0	4.7
32....	7.9	8.1	4	4.4	9.1
64....	9.1	9.2	8	5.3	8.1
128....	8.0	10.1	16	8.9	7.7

Conclusions

An investigation of the effect of varying conditions of high-temperature exposure has shown that at a constant temperature the supply of oxygen is the principal factor causing stiffening of the vulcanizates. The loss of volatile plasticizers, when present, also contributes to the stiffening.

The test tube technique, developed in the course of this investigation, in which dumbbell samples are suspended in stoppered 38 by 300-mm. test tubes heated by immersion in an oil bath, appears to give results which are considerably more duplicable than those obtained by the usual aging in circulating air ovens. The test tube technique also gives somewhat better differentiation between good-heat aging and poor-heat aging compounds.

The rate of deterioration as measured by elongation change is doubled for an 18 F. increase in the exposure temperature. As measured by hardness change the rate is doubled by an increase of 42 F. Tests run at 250 F. by this method are no more reproducible than those run at 300 F.

Thermal Spalling of Fire-Clay Brick*

Fire-clay bricks are referred to as the "backbone of industry" because of their fundamental importance. In many types of furnace operations the firebrick linings are subject to rapid fluctuations in temperature, which cause stresses to develop in the brick, making them crack and spall. The service life of many furnace linings is directly related to the resistance of the brick to failure by thermal shock. In recent years the manufacturers have accomplished a great deal toward developing those properties in firebrick that are important so far as resistance to thermal shock is concerned. The testing of the bricks to determine their resistance to spalling has been accomplished either by the water dip test in which the individual heated specimens are plunged part way into cold water, or by rapidly cooling panels of heated brick by air alone or by a combination of air and water mist. The water dip test has been specified for many years in the Federal Specifications for firebrick. R. A. Heindl and W. L. Pendergast of the Bureau's refractories section recently completed an investigation of the spalling resistance of 50 brands of fire-clay brick by the standard test method of the A.S.T.M. This method involves the conditioning of a panel of brick specimens by preheating to either 1600 or 1650 C. (2900 or 3000 F.), and after cooling, subjecting it to 12 cycles of 20 min. duration of alternate heating to 1400 C. (2550 F.) and then cooling by an air-water mist. Variations from the standard panel of brick in stretcher construction were made by laying brick as headers only, and in combinations of headers and stretchers. They represent the different types of construction used in furnace linings. Although there were exceptions, most firebrick showed greater losses in header construction than in stretcher, but in some cases the type of construction had little effect. It was also found that in general a relation exists between the pressure maintained in the furnace during the preheating of the brick and their resistance to spalling. The results of this investigation, which are given in full in the January *Journal of Research* (RP 1630), will be used as a basis for the technical requirements in a proposed revision of the current Federal Specification HH-B-671 for Fire-Clay Brick.

* Reprinted from January *Technical News Bulletin* of the National Bureau of Standards, Number 333.

British Research on Iron and Steel

There has recently been published by the Iron and Steel Institute in London Special Report No. 29. This is a review of the work between 1924 and 1943 of the Joint Research Committees of the Iron and Steel Institute and the British Iron and Steel Federation. The book reviews the work of the Committee on Heterogeneity of Steel Ingots; of the Alloy Steels Research Committee; of the Steel Castings Research Committee; and the Corrosion Committee. In each case, in addition to a review of the work, there is appended a bibliography listing all the reports which have been published by the several committees. The 175-page book is bound in cloth and is packed with information for those interested in steel production and its use. The book is available through the office of the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, and is priced at 10 shillings.

Discussion of Paper on Modulus of Elasticity of Portland Cement[1]

Submitted by Stanton Walker:[2]

I have read with interest the paper by Thomas E. Stanton, and the discussion of it by L. P. Witte and W. H. Price in the December, 1944, BULLETIN, comparing the modulus of elasticity of concrete as determined by "dynamic" and "static" methods. The data presented indicate that values of modulus of elasticity determined by measurements of stress and strain are considerably lower than those based on fundamental frequency of vibration.

For the static determinations the authors reported the secant moduli. These should be expected to be lower than values determined under no load, since the stress-strain relationship for concrete is not a straight line. Values of "initial-tangent" modulus would be expected to be more nearly comparable to the dynamic values—and, perhaps, even be substantially the same.

In my paper on "Modulus of Elasticity of Concrete"[3] it was pointed out that, according to the conventional definition, "materials that are not perfectly elastic can have no modulus of elasticity." A more general definition was suggested by which it could be said that elastic materials have a constant modulus and inelastic materials a variable one. Four methods for the determination of modulus of elasticity were described which are illustrated in the accompanying Fig. 1 (also Fig. 1 in the original paper).

In that paper values of modulus of elasticity were reported for a wide range of concretes involving several series of tests and about 4000 test specimens. For one series, covering 28-day tests of different mixes, different sizes and gradings of aggregates and different consistencies, comparisons were made of the initial tangent modulus with the secant and tangent moduli measured at 5, 10, 15, 25, and 50 per cent of the ultimate load. The accompanying Fig. 2 (Fig. 35 of the original paper) summarizes the average relationships found.

These data serve to explain why Mr. Stanton found relatively lower values of static modulus than dynamic modulus for the weaker concrete. The 1000 psi. to which he extended the secant was a higher percentage of the ultimate load than in the case of the stronger concrete. As already stated Fig. 2 is based on 28-day tests. In Mr. Stanton's Table II the average 28-day strength was 3320 psi. The average secant modulus, determined at 1000 psi., was 77 per cent of the average dynamic modulus (79 per cent if the possibly fatigued group 3 is omitted). The 1000-psi. load is 30 per cent of the ultimate, and it is of interest to note, from Fig. 2, that the secant modulus at 30 per cent is 80 per cent of the initial tangent modulus. A similarly satisfactory comparison is shown for the 28-day tests in Mr. Stanton's Table III. The agreement is not so good for the field specimens in his Table I; perhaps curing conditions affected the results.

Witte and Price do not state at what point they determined the secant modulus. Considering the average of all data, the compressive strength was 6020 psi. for the specimens on which the modulus of elasticity was measured and the secant modulus was 91 per cent of the dynamic modulus. If Witte and Price's measurements were made at 1000 psi. that would be about 17 per cent of the ultimate. According to Fig. 2 the secant modulus at 17 per cent should be about 85 per cent of the initial modulus.

The preceding suggests that a much closer relationship may exist between values of modulus of elasticity of concrete as determined dynamically and statically than suggested by the authors. The belief is supported by the data on steel (an elastic material for which the "secant" and "initial tangent" moduli would be the same) reported by Witte and Price.

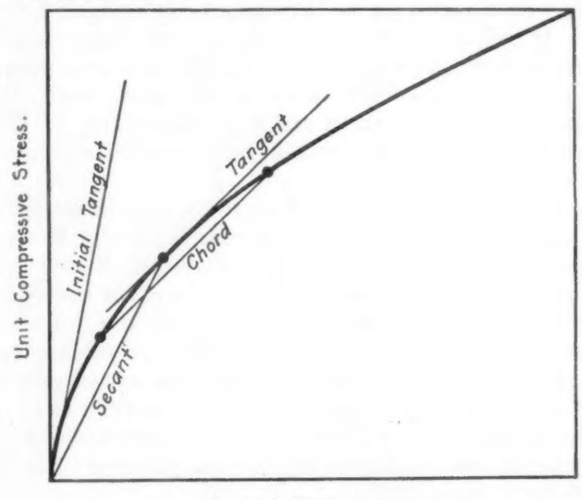


Fig. 1.—Four Methods of Determining Modulus of Elasticity from Stress-Deformation Curve. Curvature is exaggerated to bring out relations clearly.

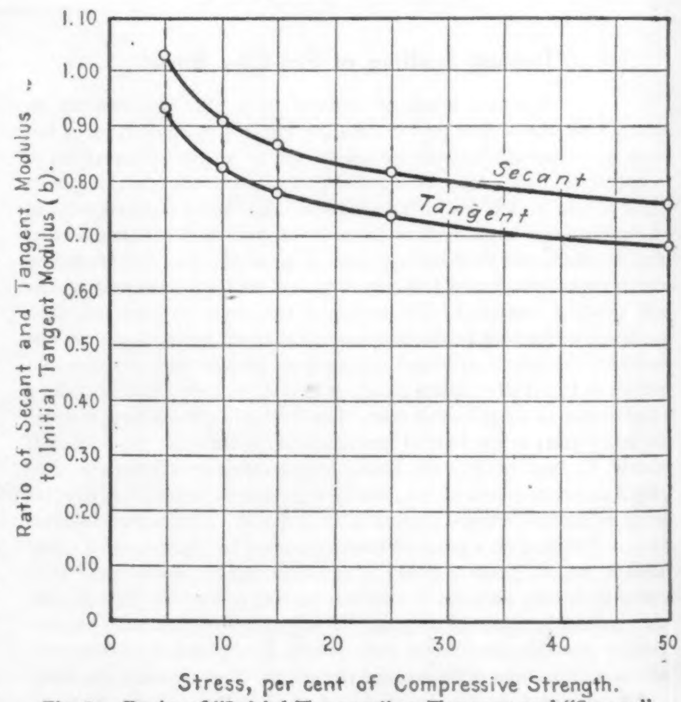


Fig 2.—Ratio of "Initial Tangent" to Tangent and "Secant" Moduli at Different Percentages of the Load.

[1] Thomas E. Stanton, "Tests Comparing the Modulus of Elasticity of Portland Cement Concrete as Determined by the Dynamic (Sonic) and Compression (Secant at 1000 psi.) Methods," ASTM BULLETIN No. 131, December, 1944, p. 17.

[2] Director of Engineering, National Sand and Gravel Assn., Washington, D. C.

[3] Stanton Walker, "Modulus of Elasticity of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part II, p. 510 (1919); reprinted as Bulletin 5, Structural Materials Research Laboratory, Lewis Institute, Chicago.

Actions on Standards

(*Continued from page 9*)

Revision in Standards on Rubber:

Added to the tests for changes in properties in rubber materials and liquids (D 471) are two additional standard reference fuels for gasoline tests which will meet urgent needs of the automotive and aeronautical industries. Changes in the tests for hard rubber products (D 530) involve the method of sample preparation and the procedure for application of the Rockwell hardness test. Since specifications for hydraulic brake hose require a low temperature bend test, a standardized procedure for this property has been added to the test for hydraulic brake hose (D 571). In the interest of standardization and to avoid complications in testing sponge rubbers of different apparent densities, the committee is concentrating on the $^1/_2$-in. slab in the test for cellular rubber products (D 552). Changes in the oven test for aging (D 573) will eventually provide for a temperature of 100 C. for use with synthetic rubber compounds, the lower temperature now in the methods being entirely too slow with various synthetics. The provisions in the tentative methods for indentation of rubber with the durometer (D 676), which methods have been long and intensively discussed, provide for an amplified scope clause giving a better description of the applicability of the method, a temperature of test is set up for tests at low temperatures, and the time at which the reading shall be taken is also specified. Concerning this latter there have been two fields of thought—whether to use an immediate reading or a delayed reading.

Electrical Insulating Materials:

With a large number of specifications and test methods in its charge, Committee D-9 on Electrical Insulating Materials is constantly striving to keep the various requirements in line with current practices and current terminology. Revisions in the test for power factor and dielectric constant (D 150) are primarily editorial, occasioned by the new term "dielectric dissipation." No changes are involved in the procedure. A dielectric strength test to be made under elongation and revisions in the methods of sampling have been incorporated in the tentative test for varnished cloth and cloth tapes, D 295. The modifications in the specifications for varnished tubing (D 372) will permit inclusion of material such as rayon and glass fiber and in the methods of test for this material (D 350) corresponding changes eventually will be incorporated. Now the recommendation sets up modifications as tentative revisions. The term "varnished tubing" hereafter is to be changed to be "treated sleeving." A new flexural test method has been developed which will be incorporated eventually in the standard method of test for sheet and plate materials, D 229. Corresponding changes are made in the specifications for varnished cloth tubing, D 372.

Plastics:

Reference to the procedure for measuring the flow properties of thermoplastic molding materials, D 569, is made in another article in this BULLETIN outlining some of the numerous activities of Committee D-20 on Plastics. There is much interest in flow properties, various changes have been developed, and the committee has asked that the standard be reverted to tentative with the changes incorporated. This test covers a procedure for determining the temperatures at which the material attains a defined degree of flow, or the degree of flow attained when subject to a prescribed pressure and temperature.

Because of the need to evaluate some of the softer types of elastomers, changes were needed in the test for resistance to accelerated service conditions, D 756. Although there were a number of comments and negative votes on proposed revisions in the standard methods of test for deformation of plastics under load, D 621 – 43, the changes have been approved because of the widespread convictions that the test conditions added are needed. At the same time, the standard is being reverted to the status of tentative. Meanwhile, Committee D-20 is giving detailed study to the method.

Plastics Committee Takes Numerous Actions at Two-Day Meetings

RESULTING FROM the intensive two-day series of meetings held by Committee D-20 on Plastics and its numerous subcommittees and sections in Atlantic City in late October are a number of important actions resulting in new and revised specifications and test methods. Interesting results from the committee's several research investigations were also reported and discussed. These meetings were held following the two-day series of Committee D-9 on Electrical Insulating Materials, a news account of which appeared in the December BULLETIN.

Elsewhere in this BULLETIN there is an article noting actions on standards approved by the Society's Standards Committee. Several items relate to the plastics field.

Hardness.—In the work on hardness properties a review is to be made of A.S.T.M., Joint Army-Navy, and Federal Specifications in an effort to reconcile hardness test procedures. A proposed method for blocking resistance has been drafted and in the extensive study of 25 materials on which several different scratch resistance procedures were to be tried a considerable amount of data has resulted. Another new development is the drafting of a test method using total indentation, recoverable indentation, and cold flow.

Permanence.—In the Tentative Test for Colorfastness of Plastics to Light (D 620) revisions will eventually be incorporated setting up controls on the lamp used, much the same as embodied in the Test for Accelerated Weathering of Plastics (D 795). The long range objective in this work is to get an accelerated test to match within reason outdoor results.

A proposed procedure for determining weight loss on heating for 72 hr. at 180 F. has been drafted. It is the intent to have this applicable to both rigid and nonrigid materials. A very extensive series of investigative tests using the various procedures established in the Methods for Resistance to Accelerated Service Conditions (D 756) has resulted in the accumulation of considerable data. The committee is desirous of obtaining not only test results, but field experience. In work on the temporary effect of heat a report from the series of tests shows that subjecting material for 15 minutes to temperatures well below those used in molding altered physical properties of some materials quite markedly, and recovery of original properties required several days.

Analytical Methods.—To develop a satisfactory procedure for detecting and determining reworked material, a series of moldings has been made representing an original and five successive reworkings. These samples will be submitted to cooperative investigation. Previous research has indicated that measurement of percentage insoluble is not a conclusive test. Revisions in Methods D 817 covering determination of acetyl and butyryl in cellulose acetate butyrate have been approved. Work on determination of other compounds is under way including the determination of ammonia in closure materials. A tentative test has been drafted and is to be the subject of a round-robin investigation.

Research.—The Subcommittee on Research considered in some detail a new plastics research project at Massachusetts Institute of Technology being sponsored by P.M.M.A.,

the subcommittee having been asked to act in the capacity of advisers. A number of recommendations resulted from the discussion, which are being transmitted through appropriate channels.

Strength.—Progress was reported on the development of test methods for measuring shear strength and bearing strength. The flexural strength method (D 790) is to be revised to make it suitable for testing laminated materials. Also, some work is being done on double loading of the flexural test specimens. The scopes of tensile strength methods D 638 and D 651 will be correlated. Method D 638 may be used for both routine checking of materials and for obtaining fundamental strength data while Method D 651, using the "dog-bone" specimen, is useful for routine checking only. A "round-robin" is in progress on measuring the tensile strength of thin films and foils. Plans were made to start work on test methods for measuring the strength of tubing and for measuring the flexibility of materials by a mandrel bend test.

Thermal.—A thorough study of the test for deformation under load (D 621) is to be made. Consideration will be given to all types of materials so that standard test conditions will be available for evaluating the cold flow of very soft elastomers as well as rigid thermosetting materials. Balloting is under way to add to the method for distortion under heat (D 648) a revision allowing the use of a built-up test specimen. Recently a procedure for testing very soft elastomers has been added to the method of test for resistance to accelerated service conditions (D 756).

Molds and Molding Processes.—Molding of test specimens is a most important matter in the plastics field and considerable work has been done and more is under way. Round-robin tests on 5-cavity *versus* single-cavity bar mold indicate on the basis of preliminary data that the use of the 5-cavity mold is open to question. Revisions have been approved and will be incorporated in the tentative standard D 796. The subcommittee is to draft a method of plastic flow using the spiral principle. The method will be circulated for comment. Excellent progress is being made in the procedure for determining bulk factor of non-pouring compound.

Definitions and Nomenclature.—Recommendations eventually to come from work on nomenclature and definitions will be of great interest to all in the plastics field. Discussion of proposed definitions resulting from considerable preliminary work resulted in approval to submit to letter ballot of Committee D-20 a number of recommendations covering the term plastic (both noun and adjective); thermosetting material (noun) and thermosetting (adjective); nonrigid material; and metastable condition.

Some of the *proposed* definitions follow:

A *plastic* (noun) is any one of a large varied group of materials, wholly or primarily organic in composition, which may be formed into useful shapes by the application, singly or together, of heat and pressure.

The adjective *plastic* may have two meanings: (*a*) preferred means capable of being shaped, while (*b*) may mean the material of which an article is made.

A *nonrigid plastic* is one which has a stiffness or apparent modulus of elasticity of not over 50,000 psi. at 25 C. when determined according to A.S.T.M. test method D 747 – 43 T.

Metastable expresses an unstable condition of a plastic during which time it is rapidly changing its physical characteristics. It refers, for example, to the temporary rubbery condition of some plastics after molding. No physical tests should be made while a plastic is in a metastable condition.

Specifications.—The work in this field has been very active for the past two years and continues in this category. Subcommittee VI has developed proposed Specifications for Cast Allyl Plastic Sheets, Rods, Tubes, and Shapes, and these are being voted on. Changes are in the offing involving Specifications for Phenolic Molding Compounds (D 700); Laminated Materials (D 709); Vinyls (D 708 and D 727); and Cellulose Acetate (D 786). A specification for polystyrene sheets is being prepared. Revision in the ethyl cellulose plastics (D 787), adding requirements for tensile strength, is being balloted upon. Experimental work and studies are in progress on other aspects involving specifications.

Robert Burns, chairman of Committee D-20, presided at the main committee meeting and at the Advisory Committee session, with L. W. A. Meyer secretary.

Proposed Test Methods for Aromatic Hydrocarbons

Several proposed testing procedures and specifications for industrial aromatic hydrocarbons have been developed by A.S.T.M. Committee D-16. Actual work has been carried out in the subcommittees which cover test methods for crude and for refined aromatic products and also specifications for aromatic chemicals and solvents.

Organization of this new A.S.T.M. standing committee was completed in 1944.

The committee is anxious to stimulate constructive comment on the proposed tests and specifications which are based on practices in current use. The list of items follows:

Methods of Test for Crude Aromatic Products

Determining Refined Water White Constituents in Light Oil

Methods of Test for Refined Aromatic Products

Scope	Distillation (Aromatic Hydrocarbons)
Color	Acid Wash (Benzene, Toluene, Xylenes, and Similar Materials)
Specific Gravity	Solidifying Point (Benzene)
Detection of Hydrogen Sulfide and Sulfur Dioxide	Paraffins
Copper Corrosion Test	Acidity

Specifications for Aromatic Chemicals

Nitration Grade Benzene	Industrial Grade Toluene
Industrial Grade Benzene	Nitration Grade Xylene
Nitration Grade Toluene	Five Degree Xylene

Specifications for Aromatic Solvents

Industrial 90 Benzene	Refined Solvent Naphtha
Ten Degree Xylene	Crude Light Solvent Naphtha
Industrial Xylene	Crude Heavy Solvent Naphtha

Those interested in studying the methods and specifications may obtain copies from the Committee's Acting Secretary, W. L. Douthett, The Texas Company, 135 E. Forty-second St., New York 17, N. Y. J. M. Weiss, Consulting Chemical Engineer, New York, is chairman of this A.S.T.M. standing committee.

Heavy Attendance at New York Meeting on Processing Materials from Petroleum

An audience of over 500 heard a most interesting technical presentation and demonstration by Dr. J. C. Dean of the Socony-Vacuum Oil Co., New York, at the meeting on January 17 sponsored by the A.S.T.M. New York District Committee. The general subject, Processing Materials from Petroleum, drew a heavy attendance, particularly from the chemists and chemical engineers in the metropolitan area. The meeting held in the Engineering Societies' Building also included a showing of the motion picture, "The Big Inch," through the courtesy of the Barrett Division, Allied Chemical and Dye Corp.

Following the introduction by Myron Park Davis, Chairman of the New York District Committee, of senior Vice-President J. R. Townsend, Past-President T. G. Delbridge took over as Technical Chairman. He referred to the intensive activity of the Society, and specifically commented on the work of Committee D-2 on Petroleum Products and Lubricants, which had very intensive meetings in Detroit, the previous two days.

Dr. Dean, a graduate of Yale and active in the development of a large number of petroleum-processed materials, adopted a combination of lecturing, demonstrating, and experimenting which was very effective in emphasizing to the excellent crowd not only the large number of products, but also the very widespread applications possible. The following synopsis of his talk refers to some of the more salient features brought out.

A great many important chemical compounds are being derived from petroleum, and the industry is very definitely in the chemical business. Few realize the very wide uses of petroleum as a processing material—clothes, furniture, paper, and a great many other products contain a petroleum derivative, or petroleum is effectively used in their production.

Over 700,000,000 lb. of paraffin wax are produced each year; this coming from material taken from light spindle oils so that these oils will continue to flow at low temperatures. About 80 per cent of the product is used on paper or paper products. Food and drink containers are important applications, and other common paper products. Paper bomb rings (oil treated) are used to trundle some of the heavy bombs to the planes. Another important war use is fuel tablets for the Armed Forces.

A big brother of paraffin is microcrystalline wax, which at one time was the ugly duckling of the industry. Petrolatum is the source. At first designated as mineral beeswax, it was used for coatings for electrical parts, and later in coating paper. Doctor Dean twisted a small rod of microcrystalline wax into a spiral showing its ductility, whereas a rod of paraffin broke in several places. Microcrystalline waxes are used to line beer cans, barrels and tank cars, and in high-grade inks to prevent "skinning." Many of these uses have been discontinued, because these waxes have gone to war—particularly in connection with methods of packaging war matériel. Some of the packaged parts can be immersed in salt water for long periods of time without damage. Production of microcrystalline wax is now six or seven times 1941's figure of 2,000,000 lb. Dr. Dean pointed to this as a magnificent achievement of the industry.

He covered the uses of wax emulsions, particularly as hot melt coatings. Wax emulsions can be stabilized with various emulsifiers and dispersing agents, and applied in amounts which can be very accurately controlled, for example, in the treatment of textiles to render them water-repellent. Millions of yards of fabrics have been so treated. These emulsions enable paper to be made water-repellent, and also enhance resistance to scuffing, provide for better printability and yield a smoother, more attractive sheet. Emulsions are used for materials other than textiles—an interesting application is their use to improve the storing properties of white potatoes and reduce loss in weight; also for treatment of potato seed. Other uses are for certain wooden articles to insure uniform drying, in ceramic pieces which are formed by high-pressure extrusion, in treatment of nursery stock, etc. Petroleum-processed materials are widely used in the manufacturing of textiles, wool, cottons, rayons, and cordage fibers. They provide stronger yarns and are better lubricants of wool fibers. For cotton, petroleum is used primarily in finishing and sizing operations. For rayon, the highly refined white oils serve as lubricants for the fibers. Even with the small percentage of oil applied, a tremendous quantity is required. Some products are applied to the yarn to set the twist before knitting or weaving.

Petroleum by-products are in wide use—an important one is the use of naphthenic acids which are converted into soaps having great utility. Some of these soaps are especially good as paint driers; some are used as fungicides and insecticides. Petroleum resins which are extracted from gasoline are useful as extenders for hard-to-get paint- and varnish-making oils.

Mineral oil sulfonates are powerful wetting agents, detergents, or mulsifying agents. There are many uses including special soaps for the armed forces. These will readily lather in hard or salt water.

As rust preventives, petroleum derivatives are most valuable. Most of the rust preventives have a petroleum base.

Among the uncompounded oils which have wide usefulness are the highly refined white oils. In addition to medicinal purposes, they are used in cosmetics, and as ingredients in animal feed.

Dr. Dean referred to the widespread use of petroleum derivatives in the rubber industry where they assist in processing, and aid in developing desirable properties in vulcanization. Finally he referred to two rather unique applications—one in the inspection of quartz so widely used in radar and radio equipment, where immersion in a petroleum liquid with the same refractive index enables the flaws to be detected quickly. The second case involved the control of the mosquito. Dr. Dean had a special slide prepared with mosquito larvae in action, and then injected a synthetic oil that is light-bodied but heavier than water. While larvae breathe on the surface of the water and oil sprays fill their respiratory organs, they feed on the bottom, and the oil that is heavier than the water sinks to the bottom and by feeding on it they are killed within a short time. He concluded by referring to the possibilities of petroleum derivatives being used as suitable carriers for some of the powerful insecticides including the new DDT.

Following the talk, there was a short discussion period of about ten minutes during which Dr. Dean, with Dr. Delbridge participating, answered a number of questions from the floor.

The program had been arranged by a committee headed by R. M. Wilhelm, C. J. Tagliabue Manufacturing Co.; other meeting arrangements were carried through by Messrs. G. O. Hiers, Secretary of the New York District Committee, and E. A. Snyder, Vice-Chairman. Prior to the meeting there was an informal dinner at the Engineers' Club with the speaker, and members of the New York District Committee and their guests present.

This local meeting is the first sponsored by the New York District for some time, and the large crowd which turned out, despite the bad storm the previous day, is indicative of the careful planning and promotion for this meeting and the interest in the subjects covered in the talk and film.

ASTM Bulletin

JANUARY 1945

NO. 132

TWO-SIXTY
SOUTH BROAD ST.
PHILADELPHIA, PENNA.

The "Testing Laboratory" of the American Society for Testing Materials

Recently while at the Society's Headquarters, a partial stranger to its activities, but sufficiently familiar with at least such a part of its work that he was representing another society in a cooperative enterprise, asked in all earnestness—"where does your Society do its testing?" I have been told by our staff that visitors have previously asked the same question.

The answer, of course, is in the "thousand and one" laboratories scattered around the country (Committee C-1's records show there are 450 laboratories equipped to test cement in the United States) engaged in determining the qualities and properties of materials—be these research institutions, plant production laboratories, plant control laboratories, purchase department laboratories, laboratories engaged in determining quality and uniformity of purchases, or the laboratories of our educational institutions, etc. The Society's membership is composed of representatives from all of these groups and these laboratories are where the American Society for Testing Materials does its testing.

It has been quite some time since testing laboratories were mostly adjuncts to the sales departments or purchasing departments of business organizations. It is true that these latter are still outstanding in the direct application of testing equipment and methods. But now as soon as a new material is produced, it is turned over to the testing laboratory to determine how nearly it approaches or how far it deviates from the properties of a commodity which it was hoped it might supplant. During the course of such testing, it is discovered that the product apparently has some outstandingly different properties not clearly or properly shown by present testing methods, and the laboratory finds itself becoming a "research" laboratory developing new test methods.

As an example in this respect, we have the presently so prominent before us silicones (but actually not as new as purported) appearing to have the nature of lubricants, synthetic resins, rubber, plastics, etc. These are now being industriously tested according to methods used for these various latter materials. But in due time when the silicones are more thoroughly understood, we will have the "testers" developing new methods to demonstrate their different properties which place them more properly in their true fields.

We should realize that materials testing, though highly specialized, is very broad. It is not confined to any industry or part thereof. It is not solely an adjunct to the sales or purchase departments. It is so broad that one does not enter the field as an adept in the profession. Rather as a chemist, a physicist or an engineer, one enters the field, and in due time becomes an adept in applying these sciences to testing—to ascertaining the properties of material.

And in the broad sense, all laboratories are testing laboratories. That is one of the reasons why our Society has a membership from all branches of so many diversified interests.

May we suggest that all interested in the broad phases of the testing laboratory and testing make Mr. Ashcroft's article in the December issue of the Bulletin "required reading." But in so doing may we also suggest that the reader should not feel that Mr. Ashcroft's discussion applies solely to the special field of textiles, but rather to the general field of testing *any* and *all* materials.

P. H. Bates

President

Chicago Meeting on Petroleum Processing Materials

Upwards of 100 members and their guests were present at the dinner meeting in Chicago on January 26 featuring a talk by President P. H. Bates on the organization and some of the work of the National Bureau of Standards, and a technical discussion and demonstration by Dr. J. C. Dean, Socony-Vacuum Oil Co., New York City. J. F. Calef, Automatic Electric Co., chairman of the Chicago District Committee, presided and W. L. Bowler, Pure Oil Co., was technical chairman. The program was arranged by George E. Stryker, Bell & Howell Co., as chairman of the District's program committee.

The meeting took the form of a dinner at the Chicago Engineers' Club. District officers cooperating with the dinner and other features were J. J. Kanter and J. de N. Macomb. Prior to the meeting there was an informal reception during which President Bates and district officers met the members and those at the session.

Following reference to some interesting phases of A.S.T.M. work, Mr. Bates who is Chief, Clay and Silicate Products Division, National Bureau of Standards, outlined the development of the Bureau and pointed to some of its major activities. Several interesting points were touched on, including the relation of the American pound and yard to the international standards in Paris (Mr. Bates mentioned that the building where these were maintained had come through the occupation in good shape). He referred to the establishment of the Bureau of Mines at which time work on structural and related materials was assigned to the Bureau of Standards. He cited the great development in the Bureau's activities, enumerated the various divisions, including the work on commercial standards and the simplified practice program,

and then described in some detail specific activities, including the important production of optical glass and the work of the Cement Reference Laboratory, a joint project of the Bureau with Committee C-1 on Cement and the Portland Cement Association.

Dr. Dean, in his interesting procedure of lecture, plus demonstration, plus experimentation, with slides, covered much of the same territory as in the New York meeting of January 17, covered elsewhere in this BULLETIN. As was the case in New York, his presentation evoked considerable discussion in the form of question and answer and it was evident that there was great interest in this subject.

Assistant to the Secretary R. J. Painter was present representing the Staff and spoke briefly.

It was announced that the District Committee is planning to participate in a War Production Conference which tentatively has been scheduled for March 29. Further details of this will be sent directly to all A.S.T.M. members and committee members in the Chicago district.

Two Sessions Feature Symposium on Magnetic Particle Testing

Eight Technical Papers at Philadelphia Meeting

UNDER THE AUSPICES of the Philadelphia District Committee, headed by L. E. Ekholm, Alan Wood Steel Co., with A. O. Schaefer of the Midvale Co. cooperating as program chairman, an outstanding symposium on magnetic particle testing was held during two sessions in Philadelphia on January 22. Some 400 were at the afternoon session with well over 500 technologists present at the evening meeting.

The very considerable work involved in planning this symposium was directed by Mr. Schaefer, and the close cooperation by the leading authorities who covered various aspects assured a successful meeting, but the very heavy attendance and the intense interest in the papers and the large amount of discussion stressed in no uncertain fashion the very widespread interest in this subject.

A list of the technical papers and authors follows:

AFTERNOON SESSION

Equipment for Magnetic Particle Inspection—A. V. DE FOREST and C. E. BETZ, Chairman of Board of Directors and Vice-President, respectively, of Magnaflux Corp.

The Magnetic Particle Test as Utilized by the Railroads—L. B. JONES, Engineer of Tests, Test Dept., The Pennsylvania Railroad Co.

Magnetic Particle Testing of Aircraft Parts—E. O. DIXON, Chief Metallurgical and Mechanical Engineer, Ladish Drop Forge Co.

Magnetic Particle Inspection, Particularly from the Standpoint of Specification Requirements—H. H. LESTER, Principal Physicist, Watertown Arsenal.

EVENING SESSION

Specifications and Procedure—A. P. SPOONER, Metallurgical Engineer, Bethlehem Steel Co., Inc.

Magnetic Powder Inspection of Castings—C. L. FREAR, Materials Engineer, Bureau of Ships, U. S. Navy Dept. (Presented by R. E. SANFORD, Materials Engineer, Philadelphia).

Magnetic Particle Inspection of Forgings—C. J. BOYLE, Works Laboratory, General Electric Co.

Miscellaneous Applications of the Magnetic Test—E. A. SNADER, Laboratory Section Engineer, Westinghouse Electric and Manufacturing Co.

Serving with Mr. Schaefer as co-chairman in the afternoon session was R. R. Moore, U. S. Naval Aircraft Factory, and in the evening, Mr. Ekholm was co-chairman. Many authorities in the industry, particularly from the east, participated in the discussion.

Abstracts of the eight papers had been published in the December ASTM BULLETIN. While no definite decision has yet been reached, there is every hope that the papers and discussion can be issued in special booklet form. Further announcement concerning this will be made.

Each author paid tribute to the value of magnetic particle testing and inspection, the symposium as a whole enumerating many applications of the test. The necessity of careful interpretation was stressed time and again and some of the participants pointed to certain limitations which, however, do not detract from the value of these non-destructive test methods.

Reference was made to the publication by the Society of the two new tentative methods of magnetic particle testing and inspecting of forgings, A275, and commercial steel castings, A272. These are in Part I of the 1944 Book of Standards and soon will be available in separate pamphlet form at 25 cents each. The Forging Manufacturers' Association has issued in special form a booklet on Magnetic Particle Testing of Commercial Forgings, copies of which can be obtained from the Association, 366 Madison Avenue, New York, 17, N. Y., at $2.00 each.

Dinner.—At the informal dinner preceding the evening session, 210 members and guests were present. At the speakers' table were officers of the Society, Philadelphia District Committee officers, and the symposium speakers. Chairman Ekholm introduced the various individuals and called on President P. H. Bates for a short talk in which he stressed the value of district meetings and complimented those who had arranged this meeting. Dinner arrangements were handled by E. J. Albert, Thwing-Albert Instrument Co.

Discussions on Magnetic Particle Testing

Written discussions of the papers in the symposium on magnetic particle testing will be received up until March 15. It is not expected manuscripts of the papers will be widely distributed, but those interested in presenting discussions should get in touch with A.S.T.M. Headquarters for the latest information on manuscripts or abstracts available.

From left to right, Theodore I. Coe, Chairman; J. W. Whittemore, First Vice-Chairman; H. D. Baylor, Second Vice-Chairman; H. C. Plummer, Secretary

Officers of Committee C-12 on Mortars for Unit Masonry.

Officers of Committee C-4 on Clay Pipe. J. C. Riedel, Chairman; D. G. Miller, Vice-Chairman; R. G. Scott, Secretary.

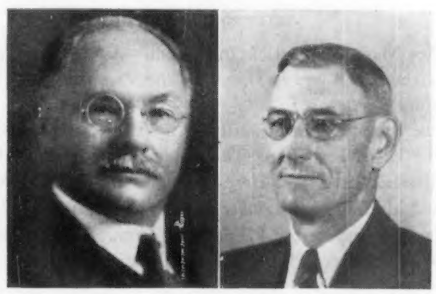
Officers of Committee D-12 on Soaps and Other Detergents. From left to right, H. P. Trevithick,* Chairman; F. W. Smither, Vice-Chairman; B. S. Van Zile, Secretary.

* *Deceased, see page 49*

Officers of Committee D-10 on Shipping Containers. From left to right, Edward Dahill, Chairman; E. R. Stivers, Secretary.

Officers of Committee B-7 on Light Metals and Alloys, Cast and Wrought. D. L. Colwell, Chairman; R. W. Waring, Vice-Chairman; J. J. Bowman, Secretary.

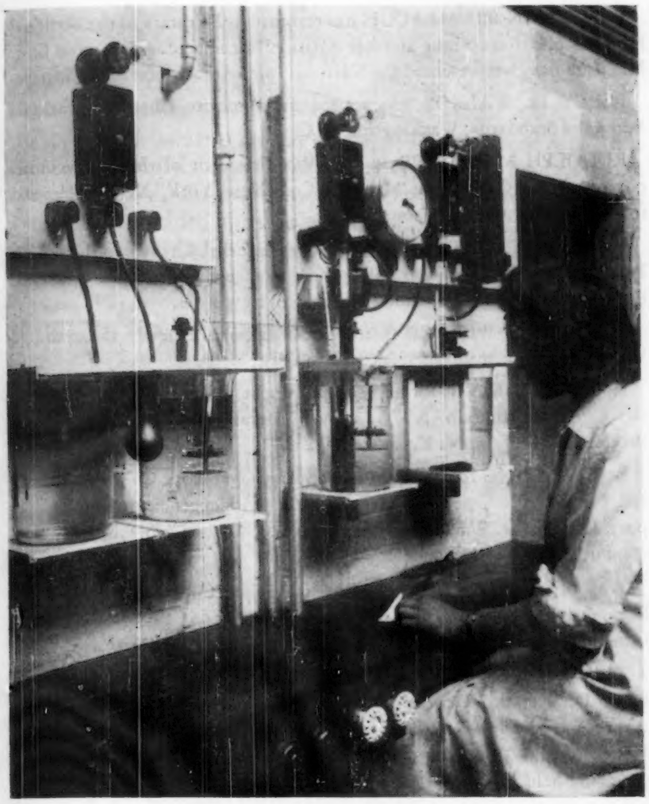
Officers of Committee C-14 on Glass and Glass Products. From left to right, Louis Navias, Chairman; E. W. Tillotson, Vice-Chairman; S. R. Scholes, Secretary.



Officers of Committee C-6 on Drain Tile. From left to right, Anson Marston, Chairman; W. J. Schlick, Secretary.

Officers of Committee D-19 on Water for Industrial Uses. From left to right, Max Hecht, Chairman; F. N. Speller, Vice-Chairman; and R. E. Hall, Secretary.

Officers of Committee B-6 on Die-Cast Metals and Alloys. From left to right, J. R. Townsend, Chairman; J. C. Fox, Vice-Chairman; G. L. Werley, Secretary.



A.S.T.M. Rapid Method for Determining Softening Points of Bituminous Material Saves Critical Labor

According to a letter received from D. M. Wilson of D. Anderson and Son Ltd., England, the Rapid Ring and Ball Softening Point test proposed by Hersberger and Overbeck, 1942 A.S.T.M. *Proceedings*, p. 889, has proved very useful in wartime England. Dr. Wilson says, "We would like to thank you very much indeed for publishing your method and to let you know that it not only saves 60 per cent of our operators' time, but the speed with which results can be obtained is very satisfactory from the works point of view." Dr. Wilson has suggested improvements in the method and these were published in the *Journal* of the Society of Chemical Industry, September, 1943, Vol. LXII, p. 140.

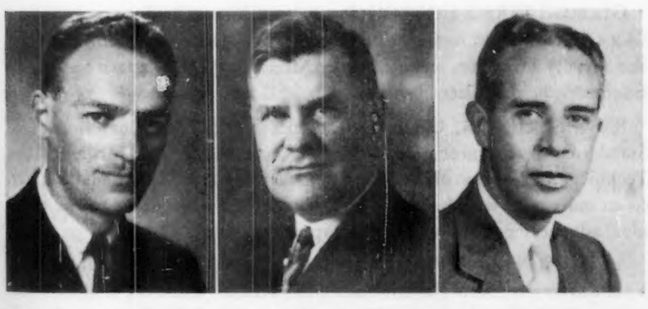
Revisions in the Emergency Specifications for Carbon-Steel Forgings for Rings for Main Reduction Gears (ES – 23a)

Change Section 9 (a) from its present form:

The forgings shall have an average Brinell hardness number of not less than 160 and not more than 190 and no individual test shall be less than 150.

to read as follows:

The forgings shall have an average Brinell hardness number of 163 to 197. No individual hardness reading shall be less than 159 nor more than 207, and the permissible range of hardness in any forging shall not be greater than 30 numbers.



Officers of Committee E-4 on Metallography. From left to right, L. L. Wyman, Chairman; R. E. Penrod, Vice-Chairman; J. J. Bowman, Secretary.

Editor's Note.—The photographs of officers of some of the Society's standing technical committees shown on this and the facing page continue the series started in the August Bulletin. No particular sequence is being followed in the series. Additional photographs will appear in succeeding Bulletins.

Catalogs and Literature Received

Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Ill. Six-page folder describing the "Precision"-Blaine Air Permeability Fineness Tester, with photograph of instrument, and paper by R. L. Blaine. describing apparatus.

Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. A new eight-page bulletin describing equipment suitable for either internally or externally heated salt pots—a Rayotube detector and a Duration-Adjusting Type of Micromax Electric Control. Illustrated. Write for Bulletin N-33B-621 (1). Also, "General Catalog" issue of "Modern Precision" a large section of which is devoted to L & N laboratory instruments. 28 pages. Write for Folder ENT (7).

W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill. Eight-page folder entitled "Dillon Tensile Tester," Bulletin No. 141. Covers various grips, auxiliary devices, etc. Profusely illustrated.

Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich. Four-page folder describing the HiTemp Dilatometer Unit. Illustrated. Also, leaflet describing the Mold Hardness Tester and the Core Hardness Tester.

The Emil Greiner Co., 161 Sixth Ave., New York 13, N. Y. Four-page folder, "The Laboratory Equipment News," describing several instruments—"Resistoflex" Gloves, Sleeve Protector, Balances, Magnifier, etc. Also, a leaflet covering the Modern Electronic Relay.

American Machine and Metals, Inc., East Moline, Ill. An eight-page folder describing the Riehle line of testing machines—Universal Machines, Impact Testers, Cement Briquette Machine, Brinell Hardness Tester, Vicker's Pyramid Machine, etc.

Corning Glass Works, Corning, N. Y. Catalog LP24 covering Pyrex Laboratory Glassware, Vycor Laboratory Glassware and Corning Laboratory Glassware. The catalog is divided into seven parts—Part I, "Pyrex" Brand Laboratory Ware; II, "Vycor" Brand Laboratory Ware; III, Fritted Ware; IV, "Lifetime Red" Low Actinic Ware; V, Alkali Resistant (Boron-Free) Ware; VI, Pharmaceutical Ware; and VII, Tubing and Rod. A subject index is included in the back of the catalog. Profusely illustrated.

Baldwin Southwark Division, The Baldwin Locomotive Works, Philadelphia 42, Pa. Bulletin 161, 40 pages, entitled "Baldwin Southwark Tate-Emery Testing Machines." Describes versatility, advantages, construction and operation, the indicating system, the straining system, the weighing system, high capacity floor type, horizontal testing machines, cement testing machines, etc.

Schaar & Co., 754 W. Lexington St., Chicago 7, Ill. Catalog No. 44, Part I, entitled "Selected Laboratory Equipment" listing the complete lines of laboratory glassware made by Corning Glass Works and Kimbel Glass Co., and the complete line of chemical and scientific porcelain ware made by Coors Porcelain Works, as well as a wide variety of special instruments and utensils in their latest modifications. Includes an index in the back of the catalog. Illustrated profusely.

Personals

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

EARL JACK SWAILES, formerly Director of Quality, American Aviation Corp., Jamestown, N. Y., is now Staff Assistant to Production Manager, Glenn L. Martin Co., Baltimore 3, Md.

HAROLD R. ALLEY, who was Technical Director, Tested Papers of America, Inc., Chicago, Ill., is now Associate Research Director, Research and Development Department Standard Cap and Seal Corp., Chicago, Ill.

ANTHONY SKETT is Assistant to Director of New Products Development, R.B.H. Dispersions, Inc., Bound Brook, N. J. He was connected with The American Gum Importers Laboratories, Inc., Brooklyn, N. Y., as Director of Research.

BENJAMIN MARSH FREES, JR., formerly with Northrop Aircraft, Inc., and later in the U. S. Navy, has now become associated with Earle M. Jorgensen Co., Los Angeles, Calif.

WILLIAM HOWLETT GARDNER, formerly connected with the Conservation Division of the War Production Board, Washington, D. C., is now Chemist, New Products Division, Sales Department, National Aniline Division, Allied Chemical and Dye Corp., c/o Chemistry Department, Fordham University, Bronx, N. Y.

For many years The British Electrical and Allied Industries Research Association has been represented in the Society membership by its Director and Secretary E. B. WEDMORE, who will shortly be retiring from active service. A. E. TOOKE, Director, will now represent the Association in place of Mr. Wedmore.

HAROLD LESLIE CHAMBERLAIN, formerly with the British Raw Materials Mission, Washington, D. C., has returned to the Research Department, Tube Investments, Ltd., Aston, Birmingham, England, as Metallurgical Engineer.

JOHAN BJORKSTEN is now Partner, ABC Packaging Co., Quincy, Ill. He was formerly Chemical Director, Quaker Chemical Products Corp., Conshohocken, Pa.

WILEY C. SMITH is Assistant to Vice-Chairman, Federal Specifications Executive Committee, Procurement Division, U. S. Treasury Department, Washington, D. C. He was formerly Consultant, Chemical Materials Section, Conservation Division, War Production Board, Washington, D. C.

JOHN N. BACCASH, who was Technical Executive, Frank Ix and Sons, Inc., New York, N. Y., is now Chief Technician and Production Manager, H. Warshow and Sons, Inc., New York, N. Y.

HERBERT B. REYNOLDS, until recently Superintendent of Motive Power of the IRT Division of the New York City Transit System, has been given the duties of Superintendent of Power General for the entire system which is a consolidation of the Interborough Rapid Transit Co., the Brooklyn Manhattan Transit Co., and the Independent System. In this position he has charge of all the power stations in the system which have a generator capacity of 600,000 kw. and produce 1,600,000,000 kw.-hr. of electric power per year.

National Malleable and Steel Casting Co., Cleveland, Ohio, announces the appointment of HOWARD W. GILBERT as Engineering Assistant to President in charge of Specialty Engineering, Development and Testing.

HERBERT F. MOORE, A.S.T.M. Past-President, has retired from active service on the faculty of the University of Illinois, and is now Research Professor of Engineering Materials, Emeritus.

L. M. STEWART, formerly Chief Engineer, Haller Engineers Associates, Inc., Cambridge, Mass., is now President, Stewart Associates, Inc., Cambridge.

ELWOOD T. LARKIN is now Consultant, Internal Combustion Engines, Buffalo, N. Y. He was Chief Engineer, Sterling Engine Co., Buffalo.

MAX SCHUSTER, who was Director, Bureau of Standards, L. Bamberger and Co., Newark N. J., is now in Merchandise Development, Bureau of Standards, R. H. Macy and Co., Inc., New York, N. Y.

W. VERNON BRUMBAUGH has resigned as Secretary of the National Lime Association to take another position in the trade association field. Mr. Brumbaugh represented the National Lime Association in the Society.

PERCY H. WALKER has retired as Associate Chemist, National Bureau of Standards, Washington, D. C.

RUDOLPH M. ASHNER is now Vice-President of the newly incorporated Plant Organizing Methods Co., New York, N. Y. He was formerly a Partner in the company.

CHARLES T. RABER has resigned as General Chemist, Glens Falls Portland Cement Co., Glens Falls, N. Y. to accept a position as Chemical Engineer with Giant Portland Cement Co., Egypt, Pa.

HERBERT L. WERNER is now President of the newly incorporated Werner Textile Consultants, Inc., New York, N. Y.

HAROLD R. KING, formerly Metallurgist, Metal and Alloy Specialties Co., Inc., Buffalo, N. Y., is now Metallurgist, McCallum-Hatch Bronze Co., Buffalo, N. Y.

R. W. WARING has resigned from Sperry Gyroscope Co., Inc., Brooklyn, N. Y., to become associated with the Bridgeport Brass Co., Bridgeport, Conn. Mr. Waring has been active on various A.S.T.M. technical committees in the metals field.

CHARLES A. BROWN has retired from The Lukenheimer Co. as of December 31, 1944, and has been succeeded as First Vice-President and General Manager by Frank P. Rhame.

ZAY JEFFRIES, who was formerly Technical Director, Incandescent Lamp Department, General Electric Co., Nela Park, Cleveland, Ohio, was recently made a Vice-President of the company and will be located in Pittsfield, Mass. His new responsibilities will involve the chemical engineering field, particularly plastics.

W. M. BARR, formerly Chief Chemical and Metallurgical Engineer, Union Pacific Railroad Co., Omaha, Nebr., has been promoted to the post of Research and Standards Consultant for the railroad. Dr. Barr has been in charge of laboratories, water supply, inspection, tests of materials and specifications of materials for the Union Pacific, and has done outstanding work in the improvement and handling of water supplies for locomotives and the development of alloy-steel forgings for railway service, including work on high-speed light-weight trains. He is a past-president of the Society, and serves on several A.S.T.M. committees.

EARNSHAW COOK, Metallurgist, Metallurgical Department, American Brake Shoe and Foundry Co., Mahwah, N. J., was one of the three co-authors of a paper describing a quantitative study of the transformation reaction of steel from high to low temperatures in heat-treating practices to receive the Henry Marion Howe Medal of the American Society for Metals. The Medal was presented for the best paper to appear in the Society's *Transactions*.

GEORGE TERRY HORTON, President, Chicago Bridge and Iron Co., Chicago, Ill., was a recipient of a certificate of Honorary Membership at the Seventy-fifth Anniversary Dinner Meeting of the Western Society of Engineers, held in December.

B. W. SCRIBNER, Chief of the Paper Section, National Bureau of Standards, Washington, D. C., will receive the TAPPI Medal of the Technical Association of the Pulp and Paper Industry. The Medal is given to an individual who has made an outstanding contribution to the technical advancement of the pulp and paper industry.

ARTHUR PHILLIPS, Professor of Metallurgy, Hammond Laboratory, Yale University, New Haven, Conn., has been awarded the honorary degree of Doctor honoris causa by the University of São Paulo, in Brazil, where he had given a series of lectures. He was also honored by the Associãco Brasileira de Metals, which presented him with a gold medal and made him a director of the society.

ROBERT F. MEHL, Director of Metals, Research Laboratory, and Head of the Department of Metallurgy, Carnegie Institute of Technology, received the honorary degree of Doctor of Science on October 28 at the commencement exercises of Stevens Institute of Technology, in recognition of his work in the metallurgical field and of his contribution to education in Brazil.

J. B. MORROW, Pittsburgh Coal Co., Pittsburgh, Pa., was presented with the Percy Nicholls Award for the Coal Division A.I.M.E. and the Fuels Division A.S.M.E. at the Fuels Conference of the Coal Division A.I.M.E. held in Charleston, W. Va., October 30 and 31.

WILLIAM O. McMAHON has been appointed Southern Area Technical Consultant of the Gray Iron Founders' Society with headquarters in Birmingham, Ala. He was formerly Chief Foundry Metallurgist of the Sloss-Sheffield Steel and Iron Co., Birmingham, Ala.

J. RALPH FRITZE has been called to the Navy Department, Washington, D. C., to head the Manufacturing Processes Section in the Conservation Division, Office of Procurement and Material. Mr. Fritze comes to the Navy Department from the War Production Board where he spent two and one-half years with the Conservation Division serving for the past year as Chief of the Consumer and Structural Products Branch. Before joining WPB, he was Materials Engineer for the Edison General Electric Appliance Co., Chicago, Ill.

MYRON S. FALK, Consulting Engineer, New York Ordnance District, New York, N. Y., has recently received a Citation from the War Department, Army Service Forces with Civilian Award of Merit.

Central Scientific Co. has announced the election of CARYL W. DEMPESY as President and Director of the company. He was formerly an executive of The Liquid Carbonic Corp., and succeeds Paul E. Klopsteg, who has become affiliated with Northwestern Technological Institute. M. N. STATES, representative of the company in the Society, continues as Vice-President in Charge of Research and Development.

R. E. WILSON, formerly President of the Pan American Petroleum and Transport Co., a subsidiary of the Standard Oil Co. of Indiana, has been appointed Chairman and Chief Executive Officer of the latter company. Mr. Wilson, formerly an A.S.T.M. member, and active in the work, is an honorary member of Committee D-2.

HAROLD DeWITT SMITH, Treasurer and Textile Technologist, The A. M. Tenney Associates, Inc., New York, N. Y., was presented with a plaque for honorary membership at the dinner held on December 6 by the American Association of Textile Technologists. Under the constitution of the A.A.T.T., provision is made that persons who have made outstanding contributions to the advancement of the textile industry are entitled to honorary membership.

WILLIAM GAERTNER, President of the Gaertner Scientific Corp., Chicago, and member of the Society since 1923, on October 24 reached his eightieth birthday. Still very active in his company he pioneered in the development of a wide variety of scientific instruments, including many used in the astronomical field. He also has built a wide range of industrial instruments, including spectrographic equipment, interferometers, etc.

New Members to January 16, 1945

The following 126 members were elected from November 22, 1944, to January 16, 1945:

Chicago District

Lion Manufacturing Corp., D. E. Hooker, Chief Electrical Engineer, 2640 W. Belmont Ave., Chicago 18, Ill.
Magnaflux Corp., Greer Ellis, Manager, Zyglo Dept., 5900 Northwest Highway, Chicago 31, Ill.
Wilson and Co., Inc., E. W. Foote, Manager, Package and Supply Dept., 4100 S. Ashland, Chicago 9, Ill.
Chang, Arthur C. C., Design Engineer, Standard Oil Co. (Indiana), Whiting, Ind. For mail: 1414 E. Fifty-ninth St., Chicago 37, Ill.
Chicago, City of, Department of Subways and Superhighways, Philip Harrington, Commissioner of Subways and Superhighways, Room 460, 20 N. Wacker Dr., Chicago 6, Ill.
Lennox, Charles E., Manager, Equipment Div., Klenzade Products, Inc., 5861 W. Ogden Ave., Chicago 50, Ill.
McKnight, William A., Secretary-Treasurer and General Manager, William F. Jobbins, Inc., Box 230, Aurora, Ill.
Root, Joseph J., Jr., Vice-President, Union Tank Car Co., 228 N. La Salle St., Chicago 1, Ill.

Cleveland District

Hemenway, Charles A., Chief Inspector, Alliance Manufacturing Co., Alliance, Ohio. For mail: 846 S. Freedom Ave., Alliance, Ohio.
McWhorter, John Francis, Research Engineer, The Ohio Rubber Co., Willoughby, Ohio.
Rinderle, Karl T., Plant Manager, Brown Industries, Inc., Sandusky, Ohio. For mail: 804 Sycamore Line, Sandusky, Ohio.
Rogers, John L., Jr., Specification Analyst, 2131 W. Eighty-ninth St., Cleveland 2, Ohio.

Detroit District

Contracting Plasterers' International Assn., Edw. McDonnell, Secretary-Treasurer, 4755 Commonwealth Ave., Detroit 8, Mich.
Great Lakes Steel Corp., H. C. Smith, Chief Metallurgist, Ecorse, Detroit 18, Mich.
Brandeberry, John B., Professor of Engineering Mechanics, and Acting Dean, College of Engineering, University of Toledo, Toledo 6, Ohio.
Doutt, Walter C., Metallurgist, Commercial Metals Treating, Inc., 177 S. St. Clair St., Toledo 1, Ohio.
Francis, George W., Consulting Engineer, The Francis Engineering Co., 303–304 Eddy Bldg., Saginaw, Mich.
Hodgson, Robert M., Quality Engineer, Lyon, Inc., 13881 W. Chicago Blvd., Detroit 27, Mich.
Lovering, E. W., Supervisor of Methods, Michigan Division, Revere Copper and Brass Inc., 5851 W. Jefferson Ave., Detroit 9, Mich.
Schaefer, Robert E., Director of Labs., Buick Motor Division, General Motors Corp., Flint, Mich. For mail: 2102 Begole St., Flint, Mich.
Scott, Erman Orchard, Associate Professor of Engineering Mechanics, University of Toledo, Toledo 6, Ohio. For mail: 2070 Campus Rd., Toledo 6, Ohio.
Siebert, Clarence A., Associate Professor of Metallurgical Engineering, University of Michigan, East Engineering Bldg., Ann Arbor, Mich.

New York District

Affiliated Research, Inc., D. K. Alpern, Consulting Director, 239 E. Forty-fourth St., New York 17, N. Y.
Aralac, Inc., O. B. Bromley, Jr., Vice-President, 71 Vanderbilt Ave., New York 17, N. Y.
Chesebrough Manufacturing Co., Martin Ganzler, Chemist and Chief Technician, 164 Sheridan St., Perth Amboy, N. J.
General Chemical Co., E. P. Aikman, Assistant Manager, Laboratory Research, Box 149, Long Island City, N. Y.
Metaplast Co., M. A. Prince, Chief Engineer, 205 W. Nineteenth St., New York 11, N. Y.
National Resources Commission, Government of China, Department of Purchases and Stores, U. C. Hsu, Head of Testing and Inspection Section, Chungking, China. For mail: 111 Broadway, New York 6, N. Y.
Pollak Manufacturing Co., Carl Gunther, Chief Production Engineer, 541 Devon St., Arlington, N. J.
Reynolds Research, R. B. Gray, Director, Development Research, Glen Cove, Long Island, N. Y.
St. Regis Paper Co., C. H. Hartman, Technical Director, Bag Div., Room 1350, 230 Park Ave., New York 17, N. Y.
Achilles, H. E., Supervisor, Technical Service Lab., Tide Water Associated Oil Co., E. Twenty-second St., Bayonne, N. J.
Ashkinazy, Samuel B., Standards Engineer, Materials and Processes, Sperry Gyroscope Co., Great Neck, L. I., N. Y.
Bauman, H. A., Electrical Engineering Dept., Consolidated Edison Co. of New York, Inc., 708 First Ave., New York 17, N. Y.
Biffen, Frank M., Research Analytical Chemist, Johns-Manville Corp., Research Labs., Manville, N. J. For mail: 805 Osborne Ave., Plainfield, N. J.
Brohl, Earl M., Engineer of Tests, Bendix Aviation Corp., 106 Nostrand Ave., Brooklyn, N. Y. For mail: 42-29 Judge St., Elmhurst, L. I., N. Y.
Connelly, W. J., Head of Refining, Creole Petroleum Corp., Room 6600, 350 Fifth Ave., New York 1, N. Y.
Cunningham, Edward N., Rubber Technologist, Stanco Distributors, Inc., Chemical Products Dept., Room 2711, 26 Broadway, New York 4, N. Y.
Dallas, G. M., Superintendent, Loss and Damage Prevention, Railway Express Agency, Inc., 230 Park Ave., New York 17, N. Y.
Etelman, Harry I., General Manager, The Penetone Co., 74 Hudson Ave., Tenafly, N. J.
Frankel, George J., Junior Test Engineer, Arma Corp., 254 Thirty-sixth St., Brooklyn, N. Y. For mail: 3647 Broadway, New York 31, N. Y. [J]*
Granville, Walter C., Research Physicist, Interchemical Corp., Research Labs., 432 W. Forty-fifth St., New York 19, N. Y.

Gross, Theodore J., President, Container Testing Laboratories, Inc., 45 E. Twenty-second St., New York 10, N. Y.
Harrower, William, Chief Engineer, Everlasting Valve Co., 49 Fisk St., Jersey City 5, N. J.
Kann, Robert, Analytical Chemist, 106 Water St., New York 5, N. Y.
McCormack, J. E., Mechanical Engineering Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Pl., New York 3, N. Y.
Migel, Hamilton, Manager, Eastern Div., Magnaflux Corporation of New York, Room 1800, 25 W. Forty-third St., New York 18, N. Y.
O'Connell, Daniel J., Associate Professor of Civil Engineering, Manhattan College, New York, N. Y. For mail: 2840 Sedgwick Ave., New York 63, N. Y.
Polese, Albert L., The A. M. Tenney Associates, Inc., 10 E. Fortieth St., New York 16, N. Y.
Reagan, Lewis M., Editor, Lefax Society, Inc., Sheridan Bldg., Philadelphia, Pa. For mail: 99 Livingston St., Brooklyn 2, N. Y.
Rindner, Jack, Mechanical Engineer, Airadio, Inc., Stamford, Conn. For mail: 762 Brady Ave., Bronx 60, New York, N. Y. [J]
Salnikov, Ivan S., Engineer, Standard Oil Co. (New Jersey), Room 2702, 30 Rockefeller Plaza, New York 20, N. Y.
Schwartz, Jacob R., Doctor of Dental Surgery, 745 Fifth Ave., New York 22, N. Y.
Shuldener, Henry L., President and Technical Director, Water Service Laboratories, 423 W. 126th St., New York 27, N. Y.
Silard, B. A., Vice-President, Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Stroop, David V., Director, Department of Engineering, American Petroleum Inst., 50 W. Fiftieth St., New York 20, N. Y.
Whitford, A. C., Director of Research, S. Stroock and Co., Inc., Newburgh, N. Y.
Wyckoff, Norman W., General Manager, Q-O-S Corp., 39 W. Sixtieth St., New York 23, N. Y.

Northern California District

California Wire Cloth Corp., The, Ed. Rainey, Wire Mill Superintendent, 1001 Twenty-second Ave., Oakland 4, Calif.
Hall, Malcolm L., Sales Engineer, The Baldwin Locomotive Works, 2929 Nineteenth St., San Francisco 10, Calif.

Philadelphia District

Metal Window Inst., George Hingston, Executive Secretary, Cheltenham, Pa.
Pennsylvania Salt Manufacturing Co., Whitemarsh Research Laboratories, Gertrude Schutze, Librarian, Box 4388, Chestnut Hill, Philadelphia 18, Pa.
Schlichter Jute Cordage Co., The, William A. Dungan, Mill Manager, Trenton and Castor Aves., Philadelphia 34, Pa.
Textile Machine Works, J. H. Groenning, Metallurgist, Box 1382, Reading, Pa.
Cohen, Joseph, Chemist, Frankford Arsenal, Philadelphia, Pa. For mail: 400 Diamond St., Philadelphia 22, Pa.
Dalle, Joseph H., Laboratory Assistant, The B. F. Goodrich Co., Oaks, Pa. For mail: 207 Francis Ave., Norristown, Pa. [J]
Davis, Thomas F., Metallurgical Engineer, General Electric Co., 6901 Elmwood Ave., Philadelphia, Pa. For mail: 7430 Buist Ave., Philadelphia 42, Pa.
Ehnts, Fred H., Chief Engineer, Keystone Lubricating Co., Twenty-first and Lippincott Sts., Philadelphia 32, Pa. For mail: 302 Congress Ave., Lansdowne, Pa.
Slagle, George H., Manager, Beryllium Div., American Mining and Research Co., Upper Darby, Pa.
Witham, W. Clifford, Chief, Specialty Oil Section, Development Div., Sun Oil Co., Marcus Hook, Pa.

Pittsburgh District

Fulton, C. E., Chief Ceramic Engineer, Pittsburgh Plate Glass Co., Research Lab., Creighton, Pa.

St. Louis District

Clore, C. T., Plant Superintendent, Federated Metals Division, American Smelting and Refining Co., 4041 Park Ave., St. Louis 10, Mo.
Klein, Frank D., Vice-President and Technical Director, St. Louis Testing Laboratories, Inc., 2317 Chouteau Ave., St. Louis 3, Mo.

Southern California District

United States Lime Products Corp., Kennedy Ellsworth, Executive Vice-President, 1840 E. Twenty-fifth St., Los Angeles 11, Calif.
Jeffers, Paul E., Consulting Engineer, 816 W. Fifth St., Los Angeles 13, Calif.
Jones, John W., Process Analyst, Lockheed Aircraft Corp., Box 551, Burbank, Calif. For mail: 5871 Canyon Cove, Hollywood 28, Calif. [J]
Stokes, John Fraser, Design Engineer, Gilfillan Bros., Inc., Los Angeles, Calif. For mail: Suite 5, 1584 W. Washington Blvd., Los Angeles 7, Calif.

Western New York-Ontario District

Rehder, John Edward, Metallurgist, Grinnell Co. of Canada, Ltd., 2440 Dundas St. W., Toronto 9, Ont., Canada.

U. S. and Possessions

Other than A.S.T.M. Districts

Colt's Patent Fire Arms Manufacturing Co., George Webb, Director, Research and Development, 17 Van Dyke Ave., Hartford, Conn.
Container Co., The, Division of Continental Can Co., Inc., H. A. Bergstrom, Chief Chemist, Box 310, Van Wert, Ohio.
Drackett Co., The, R. A. Boyer, Director of Scientific Research, 5020 Spring Grove Ave., Cincinnati 32, Ohio.
Faichney Instrument Corp., K. S. Bleibtrey, Manager, Watertown, N.Y.
New England Box Co., The, Nathan Tufts, Vice-President and General Manager, 173 Main St., Greenfield, Mass.
Terry Steam Turbine Co., The, D. S. Seelye, Chief Engineer, Box 1200, Hartford, Conn.
Todd & Hedeen Laboratories, M. L. Todd, Partner, 180 W. First St., Waterloo, Iowa.
Utica Mutual Insurance Co., Joseph B. Shaw, Director of Engineering Research Dept., First National Bank Bldg., Utica, N. Y.
Wolverine Portland Cement Co., L. C. Nodell, Chief Chemist, 107 W. Michigan Ave., Kalamazoo 9, Mich.
Benson, Albin N., Physicist, U. S. Rubber Co., Des Moines Ordnance Plant, Des Moines, Iowa.
Berry, George W., Development Engineer, Maryland Engineering Co., Pikesville, Md. For mail: Box 7273, Asheville, N. C.
Besco, Fred E., Chief Chemist, Superior Cement Corp., Portsmouth, Ohio.
Bradley, W. A., Branch Manager, Pittsburgh Testing Laboratory, 125 S. Davie St., Greensboro, N. C.
Cameron, Muriel A., Metallurgist, Neveroil Bearing Co., 29 Foundry St., Wakefield, Mass.
Coons, Kenneth W., Professor, and Head, Department of Chemical Engineering, University of Alabama, Chemistry Bldg., University, Ala.
Ellinwood, R. S., Vice-President and General Manager, Huntington Precision Products, 1444 Washington Ave., Huntington, W. Va.
Elliott, Robert M., Research Engineer, The American Thermos Bottle Co., Norwich, Conn.
Fort Lauderdale, City of, Parks Dept., P. G. Reynolds, Superintendent of Parks, City Hall, Fort Lauderdale, Fla.
Foster, Harry David, Fire Prevention Engineer, National Bureau of Standards, Washington 25, D. C.
Gathright, Arthur B., Director, Division of Purchase and Printing, Commonwealth of Virginia, 210 Finance Bldg., Richmond 19, Va.
Gilman, C. H., Treasurer, Peters Manufacturing Co., 162 Old Colony Ave., Wollaston, Mass.
Houser, John A., Standards Dept., Harvey-Wells Communications, Inc., Southbridge, Mass.
Knapp, Ismond E., Chief, Naval Stores Research Div., Southern Regional Research Laboratory, U. S. Department of Agriculture, 2100 Robert E. Lee Blvd., New Orleans 19, La. For mail: 1605 Charlton Dr., New Orleans 19, La.
Liska, Joseph A., Engineer, Forest Products Laboratory, Madison 5, Wis.
Loebbell, Ernst, Stress Engineer, Lear, Inc., Piqua, Ohio. For mail: 211 S. Franklin St., New Bremen, Ohio.
Magrane, J. K., Chief Chemist, New England Tape Co., Inc., 30 Tower St., Hudson, Mass.
McMullen, Ernest W., Partner, Ganteaume & McMullen, 99 Chauncy St., Boston 11, Mass.
Miller, M. M., General Manager, Miller Metal Products Co., 2215 Russell St., Baltimore, Md.
Paul, D. A., Chief of Physical Testing Lab., Aluminum Company of America, Trentwood Works, Box 1451, Spokane, Wash.
Putelis, Joseph C., Assistant Chemist, Worcester Purification Works, Greenwood St., Worcester, Mass. For mail: 74 Plainfield Ave., Shrewsbury, Mass. [J]
Rob, James Darley, Construction Engineer, Rose Hill Mausoleum Co., 202 Thompson Bldg., Tulsa, Okla.
Saunders, Walter M., Jr., Chemist and Metallurgist, 184 Whittier Ave., Providence 9, R. I.
Shnitzler, Meyer J., Chief Chemist, Gillette Safety Razor Co., 15 W. First St., Boston, Mass. For mail: 17 Greenough Circle, Brookline, Mass.
Taylor, Robert S., Chief Engineer, Servel, Inc., Evansville, Ind.
Vicker, Harold A., Chief Engineer, Scranton-Spring Brook Water Service Co., 135 Jefferson Ave., Scranton 3, Pa.

Other than U. S. Possessions

Australian Glass Manufacturers Co., Pty., Ltd., Box 1, Waterloo, Sydney, N. S. W., Australia.
British Titan Products Co., Ltd., Billingham, County Durham, England.
Courtaulds, Ltd., J. A. Lloyd, Patent Dept., Foleshill Rd., Coventry, England.

English Electric Co., Ltd., The, J. K. Brown, Director of Research, Stafford, England.

Jefe Laboratories de la Red Nacional de los Ferrocarriles Españoles, (RENFE), Laboratorio de la RENFE, Estación de Atecha, Madrid Spain.

Lago Oil and Transport Co., Ltd., Technical Reference Library, Aruba, Curacao, Netherlands West Indies.

Microtecnica, Ltda., Eugene J. Schultz, Director of Foundry., Rua Roma 383, Sao Paulo, Brazil.

Nepheline Products, Ltd., R. Charlick, Superintendent, Box 430, Lakefield, Ont., Canada.

Cavada, Enrique E., First Lieutenant, Chilean Navy, Talcahuano, Chile.

Elmer, Augustus, Jr., Chief Chemist, Cia. Cubana de Cemento Portland, Cayo Mason, Cuba.

Meyer, F., South African Iron and Steel Industrial Corp., Ltd., Box 450, Pretoria, South Africa.

Millspaugh, William Hulse, Chairman, Millspaugh, Ltd., Vulcan Rd., Sheffield, England. For mail: 92 Tapton Crescent Rd., Sheffield 10, England.

Robertson, William D., Research Metallurgist, Aluminum Laboratories, Ltd., Box 84, Kingston, Ont., Canada. For mail: 220 Albert St., Kingston, Ont., Canada.

*[J]—Denotes Junior Member.

NECROLOGY

Kenneth J. Howe, Vice-President, The Thibaut & Walker Co., Long Island City, N. Y. At the time of his death Mr. Howe represented his company in its membership on Committee D-1 on Paint, Varnish, Lacquer, and Related Products with assignment to Subcommittee IX on Varnish, and also represented the Federation of Paint and Varnish Production Clubs on the Joint Committee on Paint, Varnish, and Lacquer. A past president, and one of the organizers of the Federation, he was active in other organizations including local civic and social organizations.

Walter H. Juve, Consulting Rubber Technologist, Akron, Ohio. Member since 1937. Mr. Juve was a member of Committee D-11 on Rubber and Rubber-Like Materials and was Chairman of Subcommittee XXIII on hard Rubber as well as a member of the Advisory Committee. Another of his recent services to A.S.T.M. was authorship of a paper in the Symposium on Synthetic Rubbers published last year. Mr. Juve died suddenly in the Rubber Bureau Office in Washington where for many months he had devoted a portion of his time in war production and conservation work. Late last year his youngest son was killed in Northern Italy.

Walter W. Mohr, Consulting Engineer, The Edward Valve and Manufacturing Co., Inc., East Chicago, Ind., with former residence in Calumet City, Ill. Member since 1940.

Paul M. Snyder, Sales Manager, Climax Molybdenum Co., Canton, Ohio. Member since 1938.

J. E. Waterbury, President, H. Waterbury and Sons Co., Oriskany, N. Y. Member since 1942. Mr. Waterbury was a member of Committee D-13 on Textile Materials and Subcommittee A-3 on Wool and Its Products as well as Sections I on Wool and II on Felt.

Harry A. Weaver, Jr., Steel City Testing Laboratory, Detroit, Mich. Member since 1944. Mr. Weaver was killed in the southwest in connection with his duties as Instructor in the Air Service Forces, his death occurring about a year after his father passed away. His father was widely known among A.S.T.M. members, particularly in connection with his activities in the testing machines industry.

Edgar N. Yost, Division Superintendent, Armor Plate Plant, Carnegie-Illinois Steel Corp., Gary, Ind., with former residence in Chesterton, Ind. Member since 1939.

Harry Phillips Trevithick
1886–1945

Harry Phillips Trevithick, a member of the Society since 1921 and an outstanding authority in the field of oils and fats, died on January 17, following a heart attack. He had been very active in the Society's work, particularly in connection with Committee D-12 on Soaps and Other Detergents of which group he had been the sole chairman, serving since the committee's organization in 1936. Under his leadership the committee had carried out a great deal of research work of a cooperative nature and had developed a large number of specifications and test methods. He was also a member of Committees D-1 on Paint, Varnish, Lacquer, and Related Products; D-17 on Naval Stores; and was a consulting member of Committee D-9 on Electrical Insulating Materials. A graduate of Wesleyan University and Massachusetts Institute of Technology, he had been affiliated with southern cotton oil companies, the U. S. Department of Agriculture, and since 1915 he was with the New York Produce Exchange of which he had been Chief Chemist for over 25 years. He was a past-president of the American Oil Chemists Society and active in other organizations. In his death, the Society loses a loyal and conscientious member and committee officer who had rendered notable service in establishing a sound basis of industrial practices especially in the field of soaps and detergents.

British Standard Methods for Testing Petroleum

Those who may wish to procure a copy of the fifth edition (1944) of the *Standard Methods for Testing Petroleum and its Products* which represents an extensive revision of the volume issued in 1942, can get these from A.S.T.M. Headquarters at a charge of $3 which includes shipping charges. The Society has been cooperating with the British Institute of Petroleum and a supply of the books is again available. This 500-page book includes the report of the British Standardization Committee and a large number of methods, many of which are closely related to A.S.T.M. standards. The Society's Committee D-2 is one of the organizations which the Standardization Committee has referred to in its acknowledgments.

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